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ASSISTED BY A LARGE STAFF OF COLLABORATORS

FULLY ILLUSTRATED

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Vertigine visiva to Zygotes

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Vertigine visiva. (It.) Ocular vertigo.

Vertigo (dizziness, giddiness, swimming in the head) "is that condition in which a person suffers from a sense of failing equilibrium, of falling, or of rotating." Its direct cause is probably either (1) disturbance of the cerebral circulation or (2) abnormal sensory impressions from the semicircular canals or eyes, from which the chief sensations governing equilibration are derived.

(1) In disease, vertigo is met with in faintness or loss of blood, in cerebral congestion, epilepsy, intense headache such as megrim, and other brain diseases. It is often met with as a symptom of disturbed digestion, probably from reflex effect upon the circulation in the brain. (2) Vertigo connected with ocular disturbance generally depends upon some abnormal condition, either [imbalance] spasm or paralysis of one or more of the external muscles of the eyeball. It is more commonly met with in diseases of the ear; in Menière's disease the semicircular canals are themselves the seat of disease; but frequently in disease of the middle ear vertigo is one of the symptoms complained of. (*Standard Encyclopedia*). See **Vertigo, Ocular**; and **Glaucomatous vertigo.**

Vertigo, Glaucomatous. See **Glaucomatous vertigo,** p. 5578, Vol. VII of this *Encyclopedia.*

Vertigo, Ocular. A form due to eye disease, especially from paralysis of or lack of balance in the eye muscles.

Greenwood (*Trans. Oph. Soc. Am. Med. Assocn.,* 1913) raises the question whether abnormal action of ocular muscles may not reversely affect the labyrinth through Deiter's nucleus and thus cause vertigo. He believes in fact that eye-strain is one of the commoner causes of vertigo and not the least frequent, as some believe. He reports nineteen personal cases, in nearly all of which there was astigmatic refraction with one or both meridians oblique and asymmetric, requiring head-tilting and disturbance of the normal ocular rotation and movements. Several other observers have recorded similar conditions.

Murray (*Oph. Year-Book,* p. 89, 1913) says that *ocular vertigo* is most frequently due to the following causes: 1. Errors of refraction. 2. Muscular imbalance, or heterophoria. 3. Paralysis of an extra-ocular muscle. Ocular vertigo due to heterophoria is the result of the inability of the patient to maintain single binocular vision without an excessive strain on the extra-ocular muscles; and this unconscious and continuous effort to prevent double vision is likely to cause various subjective symptoms, one of which may be vertigo. Patients with an unbalanced condition of the extra-ocular muscles are likely to complain of vertigo when riding on the cars, when viewing moving objects and when attempting to do close work. The form of heterophoria which is likely to cause the most severe form of dizziness or vertigo is hyperphoria, or an unbalanced condition of the vertical muscles of the eyes.

He adds that in this form of dizziness paralysis of one of the extraocular muscle furnishes the most severe type, and is due to the actual presence of double images. This confusion is generally overcome by the patient, who soon learns not to turn the eyes in the direction of the paralyzed muscle, or he covers one eye. Ocular defects causing vertigo may be accompanied by a nystagmus, but the ocular nystagmus is undulatory in character, is not increased by turning the eyes in any particular direction, and is not composed of a rapid and a slow excursion of the eyeball, but the excursion of the eyeball in one direction is equal to that in the other, both in extent and rapidity—a distinctly different type of nystagmus from that present in labyrinthine involvement. Vertigo occurring after the use of the eyes for close work, or on suddenly looking up from the page of a book and looking at more distant objects, or when riding on the cars, or after "shopping," is very suggestive of an ocular origin, and ocular vertigo is usually relieved by closing the eyes, by lying down or by remaining in a dark room. See, also, **Vertigo**.

Vesalius, Andreas. The "Father of Anatomy" and hence the greatest physician of all time next to Hippocrates, was very appropriately descended from a long line of doctors. His great-great-grandfather, Peter of Wesel a. R., had been a physician; his great-grandfather, Johann von Wessele, was a professor at Louvain and body-physician to the Emperor Maximilian, and even his grandfather, Eberhard, was a doctor, while, finally, his father was an apothecary to a relative of the Emperor Charles V.

Andreas himself was born at Brussels, Dec. 31, 1514. His training in the liberal arts he received at Louvain. He then studied medicine at Montpellier and Paris, where he numbered among his teachers the great Guido Guidi, the equally illustrious Winther, of Andernach on the Rhine, and, finally the famous anatomist, Jacobus Sylvius, discoverer of the fissure and the aqueduct which bear his name today. Sylvius, however, great as he was, became, later, one of Vesalius's most bitter opponents.

In those days dissections were practised exclusively on the cadavers of the lower animals. Vesalius, however, at great personal risk, stole from the gallows a human cadaver, took it home and dissected it.

"And you! Would you call it a theft!"

From these dead tissues were born the science of human anatomy. Stimulated by the staggering results of these, his first, anatomical investigations, Vesalius, a little later, took service with the army, in which position he was able to provide for himself an ample supply of appropriate material for dissection. The consequence was, the well-nigh complete overthrow of Galenic anatomy, which, though founded on dissections of the lower animals only, had ruled like a despot in the world of science for more than thirteen hundred years.

Vesalius's chief writings are: "*De corporis Humani Fabrica libri Septem*," Basil, 1543; and "*Suorum de Fabrica Corporis Humani Librorum Epitome*," Basil, 1543. These works are destined to endure as long as civilization. Two or three minor books were written by Vesalius in defense of these two.

In 1543 he became physician to the Emperor Charles V.

In 1565, while on a journey to Jerusalem, he suffered shipwreck on the Isle of Zante, and perished.

It would be impossible, in the course of two or three pages, even to list the remarkable advances made in anatomy by Vesalius. Among the most memorable of his general discoveries, however, are these: That the inferior maxilla does not consist of two bones. That the os intermaxillare does not exist in the human adult. The marrow exists in the bones of the hand. That the sternum consists not of seven parts, but of three. That there is no "imputrescible bone" in the heart. That the vena cava inferior does not originate in the liver.

His discoveries in the anatomy of our special subject are also very important. Of these we may mention the following: That the anterior humor of the eye does not resemble "the white of an egg," but water. That the hue of the iris depends not on the nature of the aqueous humor, but on pigment in the iris itself. That the crystalline lens, when removed from the eye, produces, like a convex lens of glass, an apparent enlargement of objects looked at through it. That the crystalline lens is not the essential organ of vision.

Vesalius, however, made the mistake of accepting without question the existence of the so-called retractor bulbi—a muscle which is really found in herbivora, but not in man. The discovery that this structure does not exist in the human species, is due to Vesalius's great contemporary, Gabriele Falloppio.—(T. H. S.)

Vesicants. See **Blisters**, p. 1220, Vol. II of this *Encyclopedia*.

Vesicle, Lens. Lens-sac. A vesicle formed from the lens-pit of the embryo and developing into the crystalline lens. See **Development of the eye.**

Vesicle, Ophthalmic. Same as *optic vesicle.*

Vesicle, Optic. A process of the cerebral vesicle whence the percipient parts of the eye are formed.

Vesicles, Cerebral. See **Development of the eye.**

Vesicular catarrh. A name given by Arlt to a condition closely allied to ordinary folliculosis of the conjunctiva. The tarsal conjunctiva is covered with numerous small elevations (aggregations of round cells) which have the appearance of fine sand scattered over a moist surface. Mayweg has also described this disease.

Vesicular cells. See **Bläschenzellen,** p. 1008, Vol. II of this *Encyclopedia.*

Vesicular granulations. A name given by the older writers to certain superficial nodules (probably dilated lymphatics) of trachoma.

Vesicular keratitis. See **Keratitis, Bullous,** p. 6761, Vol. IX of this *Encyclopedia.*

Vessel-cramp. Cramp of retinal vessel. Spastic ischemia. See p. 3550, Vol. V of this *Encyclopedia.*

Vessels of the eyeball. See **Bloodvessels of the eye,** p. 1228, Vol. II of this *Encyclopedia.*

Veszely, Carl Constantin. A well known Viennese surgeon and ophthalmologist. Born in 1842 at Gálgóz, Hungary, he received his medical degree at Vienna, studied ophthalmology chiefly under Stellwag, and settled at Pressburg. He was, for a number of years, surgeon-in-chief of the ophthalmic division of the Garrison Hospital No. 1 at Vienna. Here he delivered a course of lectures on ophthalmoscopic diagnosis. He died Oct. 9, 1895.—(T. H. S.)

Vetch, John. A celebrated British ophthalmologist. Born in East Lothian, Scotland, he received his medical degree in 1804 at Edinburgh, and, after a number of years in the army, settled as ophthalmologist and general practitioner in London. He was for a time physician at the Infirmary for Skin Diseases, and at the Asylum for the Recovery of Health. He died April 28, 1835.

Vetch's ophthalmologic writings are as follows: 1. *An account of the Ophthalmia which has Appeared in England since the Return of the British Army from Egypt.* (London, 1807.) 2. A Report of the Influence of a Moist Atmosphere in Aggravating the Form, and Retarding the Cure of the Infectious Ophthalmia. (*Edinburgh Jour.*, 1808, IV, pp. 151-156.) 3. Report on the Difference Between the Infectious Ophthalmia and that Produced by the Artful Application of Irritating substances to the Eye. (*Ibid.*, pp. 155-159.) 4. On the Sensibility of the Inflamed Cornea to the Transmission of Light. (*Ibid.*, p. 447.) 5. *Observations on the Treatment by Sir William Adams of* *the Ophthalmic Cases of the Army.* (London, 1818.) 6. *A Letter to Right Hon. Lord Visc. Palmerston on the Subject of the Ophthalmic Institution for the Cure of the Chelsea Pensioners.* (London, 1818.) 7. *A Practical Treatise on the Diseases of the Eye.* (London, 1820, pp. 267, 3 plates.)—(T. H. S.)

Veterinary ophthalmology. Comparative therapeutics. The science that treats of the ocular injuries and diseases of the lower animals and of their treatment is of some importance to the ophthalmic surgeon, and it is proposed to devote to them a section in this *Encyclopedia.*

For much of the matter in the following pages the Editor wishes to acknowledge at the outset the great assistance and advantage he has derived from reading the various chapters touching the subject in the *Encyclopédie Française d'Ophtalmologie,* especially those by Kalt in the ninth volume of that valuable treatise.

The literature of veterinary ophthalmology is relatively scant, and further, practical studies of the subject, particularly of the pathology and treatment, are much to be desired. These investigations should come, the Editor thinks, from the ophthalmologist rather than from the veterinarian and the former may be assured that such comparative studies will redound to the credit of his calling and will well repay the time spent upon them. As an introduction to the practical anatomy, physiology and therapeutics of the subject one may consult the various treatises that have appeared from time to time.

The Literature of Veterinary Ophthalmology.

Schleich (*Centralbl. f. prakt. Augenheilk.,* Aug., 1913; abst. in *Annals of Ophthalm.,* p. 363, April, 1915) remarks that the oldest known work on animal medicine is entitled "*Claudii Hermeri Mulomedicina Chironis.*" The extant manuscript was written in Latin in the fifteenth century and is a translation made in the fourth century from the Greek. It was edited by E. Oder, and published in 1901 by Teubner. It is valuable because it gives an insight into the veterinary literature of the Romans and Greeks, particularly the writings of Apsyrtus, the most eminent veterinarian of ancient times. He lived during the reign of Constantine the Great, writing about 334 A. D.

Publius Vegetius Renatus of Volterra published a work in the middle of the fifth century which drew largely from the "*Mulomedicina Chironis.*" This work was edited by E. Lommatsch, and published by Teubner in 1903. Its complete title is "*Publius Vegetii*

Renati Digestorum Artis Mulomedicinæ Libri." Next we have the "*Hippiatrica,*" published in the tenth century.

In the "*Claudii Hermeri Mulomedicina Chironis*" many ocular conditions and their treatment, including congenital defects, are discussed. Blood-letting is frequently mentioned. The "*Hippiatrica*" is similarly arranged. All these works describe ocular diseases and remedies as they are found in human medical literature. The knowledge of eye diseases in animals did not participate in the progress made by medicine, and especially ophthalmology, until the beginning of the nineteenth century.

Although special institutions for the study of diseases of animals were founded in all civilized countries in the eighteenth and nineteenth centuries, the ocular side was largely neglected. Some works of note appeared, but had little influence. The periodical eye inflammation known as moon-blindness, was the subject of papers by Ammon and Toggia in 1807 and 1819, while Leblanc (*Traité des Maladies des Yeux des Animaux,* 1824.—Ed.) in 1824 wrote a treatise on eye diseases, their prevention and treatment, in domestic animals. A work by Müller in 1847 showed no progress over earlier publications. Real progress dates from the early seventies of the last century, when Friedenberger and Bayer, but especially Rudolph, Berlin and Eversbusch, made lasting contributions to the subject. The two latter published a short-lived journal, the *Zeitschrift für vergleichende Augenheilkunde,* which contained some publications of merit, and with the works of Möller (*Lehrbuch der Augenheilkunde,* 1898.—Ed.) and Bayer (*Handbuch der Tierärtzlichen Chirurgie,* Vol. V, 1906.—Ed.) mark progress in this special line of work. Hirschberg's work on *Comparative Ophthalmology* and *Dioptrics of Fish and Amphibian Eyes* is part of the result of placing oculists on the staffs of institutions for the teaching of veterinarians. In 1910 the *Archiv f. Vergleichende Ophthalmologie* was founded by Gustav Freitag.

Added to the authorities quoted by Schleich may be mentioned more recent contributions to veterinary ophthalmology in section of the *Encyclopédie Française d'Ophtalmologie,* p. 449, Vol. IX, by M. Kalt; the *Contributions to the Comparative Anatomy of the Mammalian Eye,* 1901, by G. Lindsay Johnson, and the section on **Comparative ophthalmology** in the fourth volume of this *Encyclopedia.* A complete bibliography of the chief contributions to avian veterinary literature will be found on pp. 10 and 11 of the Editor's *Fundus Oculi of Birds.*

Among other monographs (also overlooked by Schleich) worthy of notice are Cadiot and Almy's *Traité de Therapeutique chirurgi-*

cale des Animaux domestiques, Paris, 1904; Nicholas' *Ophtalmologie Vétérinaire et Comparée*, 1908, and our own Joseph E. Sharp's *Text-Book of Veterinary Ophthalmology*.

In all of these valuable contributions the comparative biology, pathology and therapeutics of the lower animal have been discussed.

Methods of Examination.

The animals the ophthalmic surgeon will most frequently be called upon to examine and prescribe for will be mostly domesticated, although with the increase in number and size of our zoological gardens his advice may at any time be sought for their wild occupants. In his efforts to diagnose and treat their ailments he will be most successful if he bears in mind certain rules, particularly at the first examination—that, after all, apply equally to human patients. He should exercise the greatest patience and gentleness. Rough manners. sudden and hurried movements, a loud voice—any or all of these—will not aid him in dealing with the great majority of these generally sensitive, suspicious and high-strung creatures. He *must* be friendly with his lower animal patients, however brusquely he treats his human clientele.

Inspection is always a valuable means of diagnosis and, as a rule, should be conducted in the clear, indirect daylight of a window; small animals being placed on a table, face to the light. The assistance of someone who has the confidence of the animal—his keeper in a zoo—is almost indispensable. Do not touch the animal until it is necessary, and when it is not contraindicated the use of cocain will be an advantage.

The *oblique illumination* is employed very much as in the case of human subjects. The Priestly Smith candle (see p. 4605, Vol. VI of this *Encyclopedia*) is a useful instrument for the purpose, especially for menageries or animal hospitals where there is not a dark room equipped for the purpose. If gentleness and quiet are also brought to this form of examination it will be found very effective and most animals submit to the ordeal without much trouble. Of course dilatation of the pupil—when that is possible—by atropin or homatropin greatly facilitates the exploration of the lens and is greatly to be desired for ophthalmoscopy. *Birds*, whose pupils are not affected by (human) mydriatics, generally allow their pupils to become dilated long enough to make a satisfactory examination by the oblique method.

In the case of the *horse* his head may be fixed not only by the bridle but by holding his ears.

Veterinary ophthalmoscopy is conducted as one would examine a human subject. The great majority of mammals that the ophthalmologist will be called upon to examine present few difficulties. Kalt (*loco cit.*) favors the use of daylight as illuminant but since the introduction and perfection of the self-luminous ophthalmoscope this instrument has, in the experience of the Editor, entirely displaced the old forms of ophthalmoscopy for veterinary purposes. It renders a separate light and a *very dark* room entirely unnecessary, considerations of importance in conducting examinations in private houses, dealers' stores, zoological gardens, etc. Of course an acquaintance with the appearance of the normal fundus in the animal about to be examined is essential and this can best be acquired by viewing the ocular background of one or more normal individuals of the same species. The details of this subject, as regards *birds,* are discussed in the Editor's *Fundus Oculi of Birds;* of other classes on p. 2724, Vol. IV of this *Encyclopedia.*

The practitioner should begin by practising ophthalmoscopy on the horse, mule, donkey, ox, pig, hare, rabbit, guinea pig, sheep, dog, cat, hen, parrot, pigeon, canary and any other domestic or wild subjects at hand.

Examination of the visual acuity. It is easy enough to decide whether an animal is totally blind in both eyes, and generally not difficult, by placing a mask over the better eye to discover *complete loss of vision* in the other organ, but to determine the degree of defect in partially blind animals requires close observation—of each eye separately—the use of the oblique illumination, of the ophthalmoscope and such experiments as may (roughly) test the amount of vision. The last category will include the examination of the pupil reflexes (see **Examination of the eye**, in this *Encyclopedia*), both unilateral and consensual. The reflexes in the normal eyes of the dog and cat are very prompt and complete.

An effective test of vision in one eye—the other covered—is to hold up a favorite article of food (a lump of sugar, nut, small piece of meat, etc.) at different distances (and on different occasions) before the animal and determine from its actions whether the comestible is recognized or not. When possible the passage of the patient through a room is noted as to whether he runs into (or avoids) chairs or other articles of furniture.

Complete loss of vision in one eye (whether the animal has binocular sight or not) is, of course, a misfortune, but, as in the human subject, a certain degree of compensation comes in the course of time. For example, Bayer cites the case of a well-known race horse, excellent steeplechaser, who wore an artificial eye and yet, by turning his head slightly to one side, was able to appreciate height and distance in leaping trestles and jumping ditches.

The refraction in animals. This subject is treated at length under various sub-heads in the section **Comparative ophthalmology** of this *Encyclopedia,* but it may be added here that a rough guess at the static refraction in some animals may be made by *indirect* ophthalmoscopy. This method, since the introduction of skiascopy, is now almost forgotten by ophthalmologists but it has its advantages when the patient is a more or less dangerous animal. By far the best method in practically all cases is *skiascopy.* Most animals appear to be measurably attracted, dazed or hypnotized by the light flashed into their eyes, so that they fix the illuminated mirror (not the hand holding the lens in front of the eye under observation) and allow the observer to work out the problems of ametropia for the macular area with a fair approach to the accuracy attainable in man. Cycloplegics should be used when possible. In this connection Kalt points out that the field of illumination in skiascopy in the *horse* is not uniform but exhibits concentric zones of uneven light and shade, showing the unequal refrangibility of the ocular media.

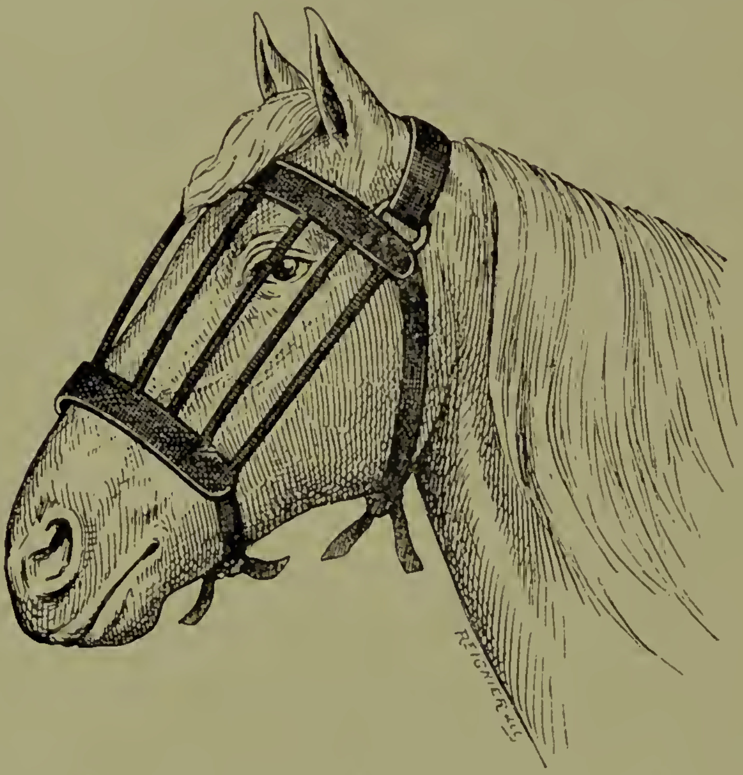
Tonometry is readily applied in most animals. It is needless to say that tonometers cannot be employed but the skilled fingers take their place with success. The ocular tension in animals as determined by the finger tips is somewhat modified by the thick sclera of some animals—the pig for example—and by the bony sclerotic plates of birds and reptiles. These facts again emphasize the need of studying the eyes of normal species before undertaking to play the part of the skilled veterinarian in a particular instance.

VETERINARY OPHTHALMIC THERAPEUTICS.

Once a proper diagnosis is made the treatment is readily indicated—just as in the case of human eyes. The success of therapy will, however, depend more upon the doctor than on his remedies. If he possess the magic power that can go only with an appreciation of the psychic attitude of his patients, if he really loves animals and knows how and when to approach them, much may be done to relieve and cure their ailments. On the other hand, a careless, stupid or brutal surgeon will make even less headway in treating a case than he would with humans who will often submit to an overbearing or ignorant attendant because there is no better one available.

As a rule *the local applications and the internal remedies employed* *in human ailments are those of greatest value in dealing with lower animal wounds and diseases.* It may not in some instances be possible to apply or administer them, and it is not contended that disease in man finds always its counterpart in every other order of vertebrates, but the observation holds good in a large percentage of cases. Here Fig. 302 p. 504, Oph. Veterinarie et Comparée.

The *therapeutics of tamed animals,* and especially of those commonly sold by dealers in bird and dog stores, bears the same relation to scientific veterinary therapy as does human domestic medicine to rational methods. A number of popular books on pet animals and their care are sold everywhere, most of which contain sensible and useful information, but beware of the ophthalmic portions of them so far as they treat of the *cure* of eye diseases! Here is an extract from an otherwise interesting booklet written by a well-known dealer: "We have cured quite a number of parrots who were apparently blind by simply rubbing in a preparation called Bird Balm."



Protective Mask for the Eyes of the Horse. (Cadiot and Almy.)

It may with truth be said that these primitive panaceas are not unknown to human ophthalmology and there can be no doubt but that bird fanciers are, as a rule, perfectly honest and sincere in furnishing these directions, and probably with their large practical experience are quite as competent to deal with ailing animal eyes as the professional veterinarian who has not made a special study of the subject. All the more reason then, that the human ophthalmologist should come to the rescue of his "brethren of fur and feather" by making a particular study of their eyes.

A good *operator* on human eyes makes, other things being equal, a successful ophthalmic veterinary surgeon, as the qualities needed for the one are also those required for the other. It is, of course, desirable that the ophthalmic therapeutist should know something of the literature of this special subject and to that end may well read the treatise of Cadiot and Almy (*Traité de thérapeutique chirurgicale des animaux domestiques.* Paris, 1904) previously referred to. Much of the following matter is abstracted from this useful work.

Pharmaceutic preparations in veterinary ophthalmology. Antiseptic solutions, collyria, eye washes, and ointments are, as a rule, prepared in precisely the same manner and used in the same (local) fashion for conditions one also finds in human eyes.

Treatment of the eyes of the larger animals. As with man, when the pain involved in any surgical procedure is not great or when immobility of the head is not essential *local anesthesia* suffices, and 1 per cent. cocain is generally effective. In many cases—more frequently than in man—the more delicate operations call for *general anesthesia.* In the case of the *horse* the plan of Dastre and Morat may be followed: inhalation of chloroform after a hypodermic of morphia-atropin. For a horse of medium size an injection of 10 to 15 cgm. of morphia, with 5 mgr. of atropin sulphate dissolved in 10 grm. of distilled water. Half an hour after this dose the chloroform is administered—60 grammes usually being required to produce complete narcosis.

For the *ox* and the *sheep* both chloroform and ether are dangerous; consequently it is preferable to give, instead of these anesthetics, and by the mouth 50 to 75 grm. of chloral hydrate, or from a half to one litre of brandy—either of which will reduce the patient to insensibility.

For operations on the *dog* one may, as a preliminary to general anesthesia, use a muzzle; or a bandage may be evenly but firmly rolled about the lower jar, crossed and passed over and around the superior maxilla and then fixed by safety pins behind the ears. The four feet are also bound. The head- and body-rest commonly used in laboratories is useful but not indispensable, especially if one quiets the animal by a preliminary injection of 5 to 10 centigrams of morphia. At the time of operation cocain (instillation of 5 per cent. solution or by some infiltration method) should be employed. A good formula for the preliminary subcutaneous injection in dogs about to be anesthetized is morphia hydrochlorate, 10 centgrms., atropia sulphate 5 milligrms., distilled water, 10 grms. Of this small dogs should have half a c.c.; medium sized animals, 1 to 2 c.c., and the largest dogs 3 to 4 c.c. Then wait twenty-five minutes before administering the chloroform or ether.

The *cat* is very sensitive to the action of the ordinary general anesthetics and is liable to die if the anesthetic is given rapidly, in too large doses, or if it is too long continued. When the operation is likely to be of short duration the animal is placed under a cover—preferably a box with a glass covered "peep-hole"—in which has been placed a cotton ball soaked in chloroform. For *prolonged narcosis* give a preliminary injection of six-tenths milligram of morphia per kilo. After the hypodermic the cat becomes much excited. In fifteen or twenty minutes (when the animal becomes quiet) it is placed under cover with several small sponges impregnated with chloroform. The inhalations of the anesthetic are continued a minute or so after the first signs of narcosis appear. There will be a revival of excitement, when the patient awakes and this state will continue for some time.

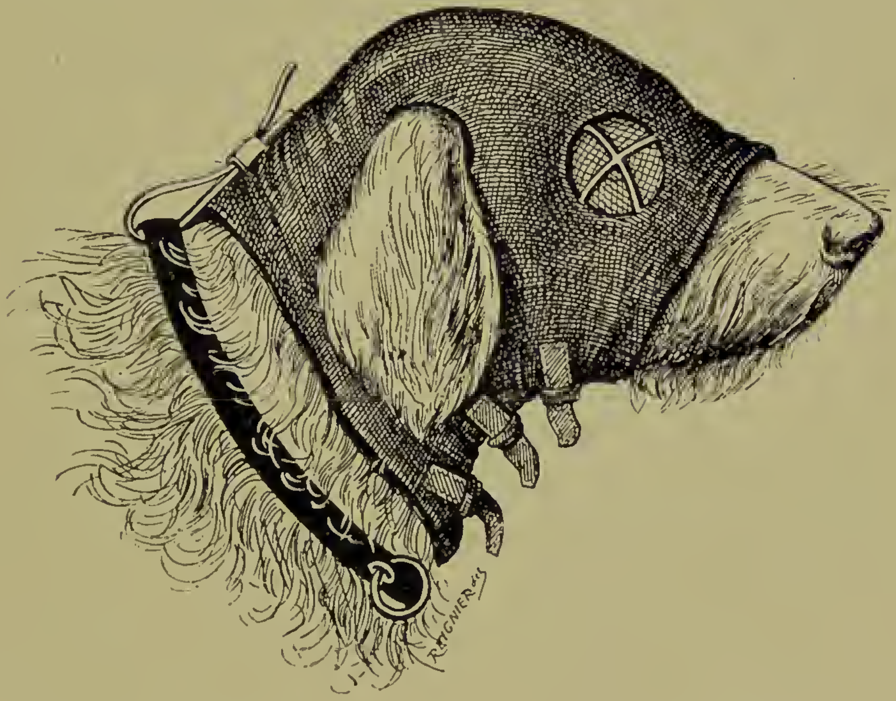
The *monkey* is anesthetized in the same manner but in a narrow cage covered with a blanket.

Birds succumb very quickly to the fumes of chloroform when placed in a convenient receptacle with a small ball of cotton wool saturated with the drug.

Application of dressings. When it is desired to exert gentle pressure and at the same time give protection to a lesion of the globe it is often better to suture the lids together for a short time than to try to keep a bandage or similar appliance on the animal's eye. Two such stitches (taking care not to injure or denude the free border of either lid) will suffice for a dog, three or four for a horse; and they may remain in place for four or five days.

In other cases the eye may be covered with layers of gauze enclosing some cotton wool, the whole being retained in place by a leather cap or mask (see the illustration) provided with removable eyelets that will permit of the dressing being changed as often as is required. When dealing with the *horse* use an apparatus made of a series of metal rods that form a kind of grill covering the face and eyes. The rods are united both above and below by two metal semicircles, the upper one placed over the forehead, the lower fixed across the nose. Straps around the ears, chin and throat keep the apparatus in place. (See the figure.) The horse is then put in his stall with his head to the rear and tied by ropes to two opposite posts so that he cannot rub the diseased eye against the wood or metal work.

Brusaco's *mask for dogs* is shown in this text. It is made of leather and covers the whole head except the ears, eyes and nose. It is secured at the neck and in front by four buckles. The eyeholes are provided with a strengthened, hemispherical wire screen. When it is found necessary the animal's legs may be shackled.



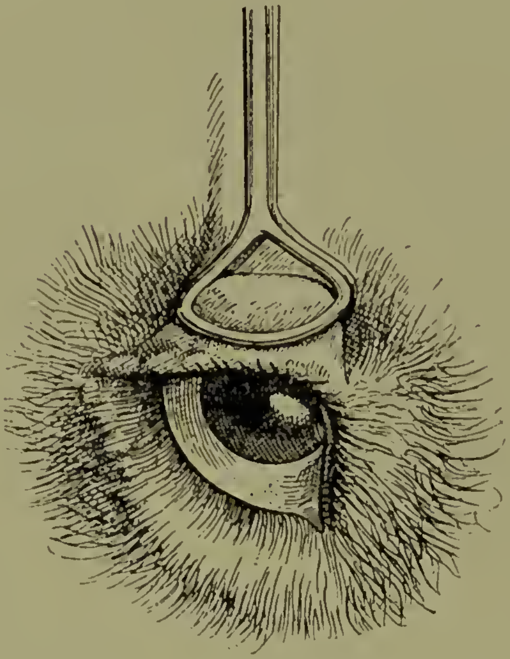
Brusasco's Mask for the Dog's Eyes. (Cadiot and Almy.)

Tuberculosis in the lower animals presents characters peculiar to the various sub-classes, and its course, clinical appearances and prognosis in eye affections also differ from those seen in man. Finnoff (see **Tuberculosis of the eye**, in this *Encyclopedia*) remarks that cattle are especially susceptible to the disease, while swine often fall victims to it. Laboratory animals, particularly the guinea pig, are susceptible to artificial inoculation but do not contract the disease under natural conditions. Chickens, pheasants, turkeys and pigeons suffer from the disease, while geese and ducks are exempt.

Diseases of the eyelids in the lower animals.

The lid skin is affected by *eczema*, with pustular eruptions and branny scales in the sheep and the horse. The ox is partially liable to a form of the disease that attacks the animal in summer and disappears in winter. According to Leblanc the cat is subject to a form of palpebral eczema of the squamous variety; the dog to a more acute variety of the disease.

Erythema of the lower lid is found in the horse at the inner angle, attended by chronic lachrymation as a result of irritation of the eyeball and its annexes. The treatment of the foregoing lies chiefly in the application of an ointment of zinc oxide, white precipitate and similar agents. See Vol. V, p. 3839 of this *Encyclopedia.*



Operative Treatment of Entropion in the Dog.
The lid skin held by forceps for excision.
(From the *Encyclopédie Française.* Cadiot and Almy.)

The dog is especially subject to *follicular mange* or *itch,* associated with dermal crusts, lesions of the true skin, ectropion, etc. Of the animal parasites, the eyelashes harbor the *Ixodes ricinus,* the *Hypoderma bovis* is found beneath the conjunctiva and a number of other animals infest the external eye, several of which are also found in the human subject. See, e. g., **Ophthalmomyaisis,** in this *Encyclopedia.*

Tuberculosis is often seen in the frontal areas of the parrot in the form of vegetative growths, and it is not uncommon in the same region in the cat. The eyelids of the larger domestic animals, however, seem to be free of this disease.

Blepharitis ciliaris of the human type is very uncommon except in the dog in whom it may be accompanied by styes.

We occasionally meet with *chalazion* in the horse.

Entropion of the cicatricial variety is uncommon in most animals, but *spasmodic entropion* is very often seen in horses and dogs, especially in those varieties of the latter that have the skin loose and abundant. The symptoms that follow this condition are much the same as in man, epiphora, conjunctivitis, corneal ulcer, etc. The apparatus that in the human being is involved in spasmodic entropion is not the same in the horse and the dog. Here the choanoid muscle (see Vol. III, p. 2072 of this *Encyclopedia*) acts in conjunction with the orbicularis and the inversion of the lid edges is rendered more marked by the retraction of the globe. Treatment of this condition invariably calls for operative interference. If thermocautery fails, then the Gaillard, Snellen-Stellwag or similar procedures must be resorted to while the animal is under a general anesthetic. The steps of the operation and the choice of operation are much the same as in man. See under the heading **Entropion** in this *Encyclopedia*. Fig. 300, p. 497, Oph. Vet. MS 14.

Ectropion is much rarer than entropion. It follows chiefly loss of the palpebral skin and is associated with some forms of chronic conjunctivitis, or with paresis of the orbicularis. It is also regarded as normal in the Saint Bernard breed of dogs. The treatment is the same as in man. See **Ectropion**.

Diseases of the conjunctiva.

To *explore the conjunctival sac* the eye need not be cocainized but the head of the animal (large or small) should be firmly held and the lids parted by retractors. Sometimes this may be accomplished by traction on the lid edges by the thumb and fingers alone but if carefully and gently carried out the instruments cause less pain and give most satisfaction. The space behind the third eyelid may be examined in the same fashion.

Catarrhal and purulent conjunctivitis in animals are quite common. The former generally arises from such external sources as dust and other foreign bodies—especially pieces of straw, grains of sand, beards of barley, smoke, and from such an infection as dacryocystitis. Koch-Weeks bacillus, most diplobacilli and the gonococcus have not been inoculated upon the eyes of lower animals. The pneumococcus injected beneath the conjunctiva of the rabbit sets up only a slight irritation, while virulent strains of the streptococcus produce a lively reaction. Thus, and in many other instances, is shown the futility, the waste of time and energy and the error of attributing to human ocular tissues pathologic and other conclusions based on animal experimentation in orders of mammalia below the Primates. The Editor has developed this argument as an editorial in the Nov., 1919, number of the *American Journal of Ophthalmology.*

Epidemics of acute conjunctivitis have, as in man, been observed in cavalry and other military outfits. In the same way Sichel observed a similar outbreak in three herds of cows. Unlike the "pink eye" of man the infection was complicated by white corneal areas that ulcerated, filled with granulations and left larger scars. The bacteriologic examination was negative.

General infections (petechial fever, horse-pox) are not infrequently associated with acute conjunctivitis, just as the conjunctival infection of variola, measles and scarlatina in man.

Purulent conjunctivitis resembles the same disease in man and is usually accompanied by general symptoms. It is most frequently seen in the ruminants and in the dog; less frequently in barn-yard fowls, and very rarely in the horse. Omega gives an interesting account of *ophthalmia neonatorum* with serious corneal complications in kittens whose mother was suffering from a purulent vaginitis. The disease extended to other cats in the neighborhood.

Kalt says that this disease is quite common in birds and may be due to parasites in the conjunctival sac and membrana nictitans. Jermolajew noted a similar occurrence in a herd of cows, while Delmer has described an acute infection with involvement of the cornea which left that ocular covering perfectly opaque.

Although examinations of the secretions in the ophthalmia of the new-born in chickens, lambs, kittens, pups, etc., have hitherto failed to demonstrate the presence of the gonococcus yet the disease in all these animals strikingly resembles the gonorrheal infection of human infants and is without doubt closely allied to it.

The *treatment of purulent ophthalmia in animals* involves an attempt to determine its cause, to remove it if possible, and then to apply much the same local remedies as have been found useful in man. Irrigation with 1:5000 to 1:3000 of mercuric cyanide once a day, meantime using more frequently a cleansing wash of warm boric acid in the form of *Kalt's lavage* (*q. v.*) will be found very effective. The lid edges should be smeared with vaseline after each irrigation and the greatest care should be taken, especially during the struggles of the patient, to avoid touching the cornea with the finger nail or with any of the appliances used in treatment. Very little, apart from this program of asepsis and antisepsis, can be done for complicating corneal ulcer but the thermocautery may be tried; or the ulcer may be touched with 1:10 formalin, followed by irrigation with 1:5000 permanganate of potassium every three hours. Atropine is also useful in mammals but is of doubtful utility in birds.

Membranous conjunctivitis, often as a part of diphtheria of other mucous membranes, affects domestic fowls, but rarely the dog, the cow or the goat. The false membrane attacks chiefly the palpebral conjunctiva but it may extend to other areas in that membrane. Secretion varies in character and amount, ulceration of both the conjunctiva and cornea may supervene, followed by loss of vision. Avian diphtheritic conjunctivitis has little to do, bacteriologically, with the Loeffler infection in man, although clinically they closely resemble one another.

The preventive treatment of this affection is very important owing to its highly contagious character. Isolation strictly carried out of all suspects and the prompt vaccine treatment of all the barnyard fowls and other susceptible contacts are the chief considerations. Two antitoxin inoculations, twelve days apart, seem to be effective. Locally, both eyes should be irrigated with weak solutions (1:4000) of sublimate or permanganate. Kalt recommends that the false membrane be removed and the denuded surface touched with spirits of turpentine.

Follicular conjunctivitis is common in the dog, and is also found in many other animals. The nodules may be so close as to give the exposed parts the appearance of a sanded surface. The hypertrophied papillæ are especially abundant beneath the third eyelid. Granular conjunctivitis in man can be transferred by inoculation only to the monkey.

Tumors of the conjunctiva.

Epithelioma and sarcoma have been observed at the limbus corneæ in the horse. These neoplasms tend to spread, may involve the ocular interior and return when excised. Enucleation followed by radium or the X-rays is indicated.

Pterygium has been seen, but rarely, in both the dog and the horse. Dermoid tumors are very rare in domestic animals; they usually occupy the external sector of the eye, but sometimes are seen in the cornea proper.

The Sclera and its diseases in the lower animals.

Hyperemia of the sclera, especially as part of a uveal congestion, is not uncommon and is more marked than in man because of the numerous blood vessels. A scleritis apart from this manifestation is practically unknown in veterinary ophthalmology. *Posterior staphyloma* is generally congenital, while anterior staphyloma (and buphthalmos) belong to the category of glaucoma. *Rupture of the sclera* may occur as we find it in man, and is generally seen at the limbus.

The Cornea and its diseases.

Although, as Kalt points out, there are chiefly two forms of inflammation of this ocular covering and we may speak of *suppurative* and *non-suppurative keratitis*, yet the signs and symptoms vary greatly in the different classes and sub-classes of animals.

Of the former there exist *abscess* and *ulcer* of the cornea, neuroparalytic keratitis and keratitis associated with lagophthalmus. The non-suppurative diseases of the cornea are, chiefly, superficial keratitis; vesicular, parenchymatous, and deep punctate keratitis and pannus.

These affections of the cornea as they are found in the lower animals will now be considered.

Superficial keratitis. This affection is marked by a removal of the anterior epithelium with or without implication of the true substance, and its cure usually depends upon the depth and extent of the corneal involvement. It follows, generally, a conjunctival catarrh, trichiasis, traumatic erosions, foreign bodies under the lids, etc. It is also seen as an accompaniment of bovine pest, sheep-pox and other eruptive diseases, appearing, first, as a vesicular eruption, and generally results in a more or less marked pannus. This sequel of non-suppurative keratitis is not uncommonly seen in the lower animals.

Parenchymatous keratitis. This disease begins generally at the corneal periphery and gradually covers the whole membrane until it presents a white or yellowish-white appearance. Vessels form in this infiltration and spread over the surface of the cornea, giving the appearance of a *pannus tenuis.*. In other words, we see a picture closely resembling the same disease in man. It quite often accompanies the various forms of animal iritis and iridocyclitis (of which it is frequently but an extension) associated with the typhoid fever and infective pneumonia of the horse, the gangrenous coryza of the ox and with certain diseases of puppies. It is seen, also, in cowpox, in the pox of the goat and in young bears confined in cages. It is also an accompaniment of tuberculosis of the anterior uveal tract—the iris and ciliary body—and with the symptoms and signs noticed in man.

Deep keratitis has been observed, according to Morax and Stock, in the course of trypanosomiasis in the goat.

Punctate keratitis, or macular corneitis, was first observed in the horse by Froehner. Later, Bayer observed eight cases in the same animal. The circumscribed corneal opacities are like ground glass but resolve themselves with a lens into minute, grayish points seen beneath the intact epithelium. The course of the disease is decidedly chronic; there is very little reaction, and the height of the attacks may not be reached for several weeks. Relapses are quite common and may occur at intervals of from one to three months, and this state of affairs may persist for years. The cause of this peculiar disease is unknown.

Deep punctate keratitis, or *descemetitis,* is (as in man) not a true corneal lesion but a sign of uveitis.

Hypopyon keratitis is the usual form of suppuration of the cornea and is a common affection in veterinary pathology. It presents a picture almost identical with that seen in man. As in the human disease the suppurative process may be arrested, or, going on to perforation of the cornea, may leave a scar with or without a hernia of the iris. In the horse the membrane of Descemet is relatively thick and so resists more successfully than in man the intraocular pressure; therefore, the perforative process does not occur as quickly or as often as in the human subject. In the ox and dog, on the other hand, keratocele from this cause is not uncommon. The etiology of the disease is much as we find it in man; and it must be remembered that the general condition, such as mal-nutrition (diabetes, common in young dogs) often acts as a predisposing cause. Undoubtedly, however, corneal traumatisms from dry wheat, hay and straw stems, branches of trees, etc., to which most animals are exposed, are the chief causes. In birds, membraneous conjunctivitis is not rare and often leads to infection of the cornea, ulcer and panophthalmitis. In the horse influenza and (equine) syphilis have been held responsible for serpent ulcer of the cornea.

Epizootic keratitis. This accompaniment of epidemic conjunctivitis, affects in particular the ruminants, especially the ox. It is also seen in the sheep, goat and pig. It is preceded by rise of temperature and accompanied by lachrymation, photophobia and the usual symptoms of an acute conjunctivitis. At first there appears at the center of the cornea a rounded papule, sometimes white, occasionally yellow, followed by an ulcer, at the base of which a fleshy granulation is seen which may become fibrous and persist indefinitely. Sometimes the ulcer perforates; in any event it may persist from two to four weeks. Occasionally what seems a rather benign kerato-conjunctivitis may terminate (without perforation) in a serous iridocyclitis.

Opinions differ as to the exact nature of this epizootic disease, which has spread all over the world; some say it is essentially microbic, others that is due to a distoma, still others that it is a sort of *ophthalmia nodosa,* and spread by injuries from stubble, briars, etc. At any rate it is not transferable to man.

The prognosis is serious since it generally affects both eyes and leads to blindness, in from 5 to 80 per cent. of cattle attacked, according to the severity of the particular epidemic. Even isolation of individuals does not seem to prevent the spread of the disease.

The *sequelæ* of the severe forms of keratitis and corneal ulcer are much the same as in the human subject. As stated, such results as perforation of the cornea, anterior polar cataract, fistula corneæ, etc., are more common in some animals than in others.

The treatment of purulent keratitis in the lower animals is much the same as in man. The most important agent is antiseptic irrigation, 1:3000 mercuric cyanide, 1:300 hydrogen peroxid, associated with iodoform ointment and atropine; and, when indicated, paracentesis of the cornea and the actual cautery for serious ulceration. Surgical interference may be difficult in those animals with powerful orbicular and retractor muscles, and care should be taken, in employing force, not to rupture the weakened cornea. Nicholas recommends curretage of the ulcer margins in these cases.

In the rather common occurrence of corneal ulcer in pet dogs hot compresses frequently repeated will be found of considerable value. If perforation threatens paracentesis followed by the use of eserin is indicated. Especially when recent, white opacities are not necessarily fatal to eyesight, as edema and exudates are much more extensive in most domestic animals than in man, and a favorable outcome may be expected more frequently than one could hope for from a similar appearance in the human cornea.

Leucomata may be tattooed, and an optical iridectomy can be employed if required.

Sympathetic ophthalmia has never been observed in the lower animal.

Vesicular keratitis (febrile herpes) is seen in the aphthous fever and "rot" in sheep; in the horse-pox and the variola of the cow and sheep. Dogs are very subject to *phlyctenules;* while true *corneal herpes* is not unknown in some animals.

Tuberculous keratitis has been observed—but it is rare—in the cow and pig; while cases of *neuroparalytic keratitis* have a few times been noted as a result of injury of the trigeminus and its branches. Keratoconus and tumors of the cornea have also been described.

Diseases of the uveal tract.

For the comparative anatomy of this region see **Comparative ophthalmology.**

The iris pigment, which in herbivora takes the form of "soot-balls," is easily detached and may be deposited (as a sort of hernia or ectropion uveæ) in the anterior chamber. This condition, very rare in human beings, is quite common in the horse, cow and sheep. It is very marked in the last named; but rarely seen and of slight degree in the dog.

The ciliary muscle is very well developed in birds and in monkeys; but slightly in the horse, cat, dog, pig, and the ruminants.

In the lower animals inflammations of the uvea are, as a result of the less intimate anatomical relations, generally of the posterior and not of the anterior segments as in man; and they are more easily divided into the two categories, iridocyclitis and choroiditis.

Iridocyclitis, however, closely resembles the same affection in the human subject, has the same signs, the same complications and—when not promptly treated—the same endings.

The study of the various forms of uveitis has been mostly carried out on the horse, and especially as a complication of *periodic fever*—a very common disease of that animal. This curious and as yet mysterious, often epidemic, general infection (probably bacterial) mostly shows itself in the eye.

The chief character of this disease is its periodicity; whether the inflammation be acute or chronic it varies in its intensity and course, relapses occurring every day or two or every few weeks or months. It may attack one eye or both.

The pathology of the disease is what one would expect from the symptoms and course. The chief alterations are the immense increase in the size of the chorio-retinal vessels and in the quantity of exudates thrown out in the course of the disease. Little by little the ciliary body is invaded, its true substance is destroyed and its place taken by a dense fibrous mass traversed by sclerosed vessels that surround the iris and even the cornea, the former organ being profoundly altered in structure. Detachment of the retina is often seen in the chronic cases, and the optic nerve fibres undergo morbid changes.

Although periodic iridocyclitis—whether it be acute, subacute or chronic—begins in some part of the uveal tract it tends—if it lasts long enough—to involve all the structures of the eyeball and especially in the chronic form corresponds to the human form of panophthalmitis.

Other varieties of iridocyclitis are seen in domestic animals, especially those accompanying respiratory diseases, typhoid fever, rheumatism, diphtheria and glanders. In France these forms are given one name, "internal ophthalmia," when they are not some variety of periodic fever.

Sometimes one observes in the cow a form of uveitis closely resembling the periodic fever of the horse, and it has been seen to break out simultaneously in droves of both animals on the same farm.

Uveitis anterior is not uncommon in young dogs.

Tuberculous iridocyclitis. As a primary infection this is a rare disease among animals. When it occurs it is almost always derived from some distant focus by way of the blood channels.

Tubercle of the ciliary body has been seen in the pig, but it is very uncommon.

Uveal tubercle has been noticed as nodules, both discrete and massed, in the iris. In the former instance the deposits are yellowish-white, of about the size of millet-seeds, scattered most profusely at the periphery, the posterior surface of the iris being covered by a fibrous exudate. The conglomerate form has been found in the ox. Beginning at the periphery the deposits spread towards the pupillary border and even project into the anterior chamber. This type of tubercle also tends to infect the ciliary body, to pierce the sclera and show itself externally as a tuberculoma.

The prognosis in all forms of tuberculous iridocyclitis is unfavorable; vision is affected seriously and the eye commonly succumbs to a general atrophy in spite of all treatment.

In France, the buyer of an animal which, within thirty days of purchase, shows signs of tuberculous eye disease has a legal right of recovery if he is able to prove by the existence of the usual signs (posterior synechiæ, exudates, pupillary paresis, etc.) that there existed evidence of the disease (*fluxion périodique*) at the time of the transaction. Here it is that the services of an expert ophthalmic veterinarian are needed, especially in the case of valuable animals (pedigreed stock, race-horses, etc.) for the purpose of deciding whether they have had previous attacks of eye disease or not. The French found at their army remount stations that nearly four per cent. of the horses had to be rejected for this disease alone.

Treatment consists in the local use of one per cent. atropin solution combined with one to two per cent. cocain. This collyrium may be used when the disease is first noticed, as often as five or six times a day; or in the very acute cases it may also be employed as an ointment, or subconjunctivally. Leeches to the angular vein and blisters may be used as adjuvants, being careful that the animal does not rub the eye. The eyes should be kept quiet and, of course, guarded against bright light.

Nicolas has advised the subconjunctival injection of from 1 to 3 cc. of mercury cyanide, 1:200, and reports that a favorable result has followed this course.

By paracentesis (under general narcosis) the exudates into the anterior chamber can be removed, and Bayer has even employed iridectomy in the very chronic cases with extensive synechiæ.

Internal treatment consists in the employment of the mixed iodides, followed by Dor, preferably the intravenous injection, every day for a week, of 10 to 20 grms. (increasing the dose day by day) in one per cent. solution. By the mouth (which seems just as effective) the first, daily dose is 20 grammes, increased gradually to 40 grammes administered two or three times a day.

Symptomatic or traumatic iridocyclitis calls for no special treatment, except that as sympathetic ophthalmia does not occur in the lower animals a precautionary enucleation is not indicated.

Tumors of the uveal tract are extremely rare in animals, although sarcoma, enchondroma and iridic cysts are described.

Persistent pupillary membrane has been observed in most domestic animals.

Especially in the horse, coloboma of the choroid and iris has been noticed, associated sometimes with microphthalmus, as Bayer mentions.

Ocular albinism, or "wall-eye," is not a rare congenital condition in animals, especially in such domestics as the great Dane, many horses, and certain varieties of the hog.

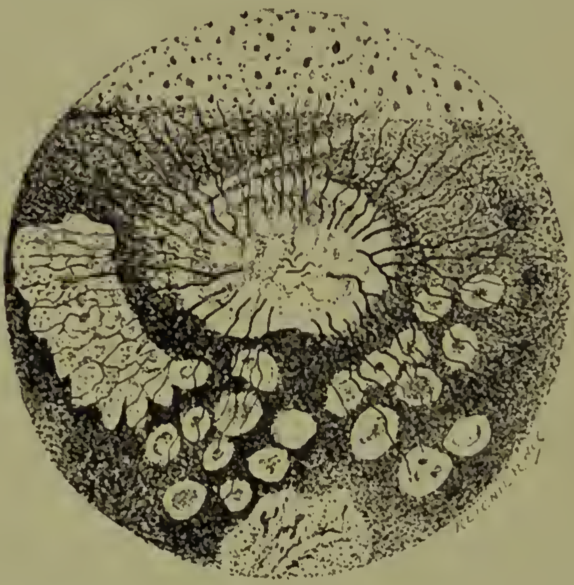
Inflammation of the choroid.

This is of very rare occurrence, except, perhaps, in the horse. We distinguish a *diffuse* form, due to the same causes as iridocyclitis, and a true *disseminated choroiditis*. The latter (see the figure) is invariably found in the inferior sectors of the fundus on both sides of the optic disc. Pathologically the disease seems to be identical with the same disease in man. Prognosis in the diffuse form is very grave;

on the contrary that of choroiditis disseminata is hopeful, and it does not to any extent affect vision, since the process is strictly peripapillary and does not involve the macular region.

Tuberculous choroiditis, whether in form the of miliary or massed deposits, is a serious though often slowly progressive disease. In the pig the conglomerate (the common) form may invade the sclera and, perforating it, appear externally as a yellowish tumor mass, varying in size from a pea to a hazel nut.

The invasion of the various parts by uveal tuberculosis in the cow and pig is about as follows: in 30 cases, the whole uvea was involved in five; in 13, the choroid alone; in 12, the anterior segment only, being limited to the iris in three instances, and in two to the ciliary body.



Disseminated Choroiditis in the Horse. (Nicolas.) (*Encyclopédie Française.*)

As to the frequency of ocular tuberculosis in the lower animals, Manleiter found that of 200 cattle (10 years of age and under) so affected by the general infection as to be unfit for food five per cent. had tuberculous eye diseases, while of 250 pigs less than a year old only 1.6 per cent. were so diseased.

Here one may refer to the possibility (discussed under **Comparative ophthalmology**) of the development of a *myopic choroiditis* in owls and, perhaps, in other animals.

A *panophthalmitis* (purulent iridocyelitis) as the result of metastasis in the course of bronchopneumonia, meningitis, etc., has already been referred to as occurring in the horse and rabbit, but this disease is generally the result of penetrating and subsequently infected wounds of the eyeball. In spite of all treatment (injections of cyanide, hot fomentations, incisions) the eye is usually destroyed and the termination of the disease is in *phthisis bulbi.* Enucleation, followed by the insertion of an artificial eye, greatly improves the cosmetic appearance of such a globe, and in valuable animals is the common practice.

Glaucoma in the lower animals.

True glaucoma is very rare in the horse, but when present is indicated by the same signs as in man.

Eversbusch reports two cases in the dog that showed the same changes—ophthalmoscopic and other—observed in human cases. Schloesser observed an acute glaucoma after injury to the lens in the rabbit, the traumatism being followed by atrophy of choroid and retina.

While adult glaucoma is a most uncommon disease in animals, *hydrophthalmus,* or the glaucoma of early life, is quite frequently seen, and presents about the same signs observed in infants. The excavation of the papilla shows very plainly in the rabbit and the dog. The disease may be congenital or it develops (generally as the result of inflammatory processes) at various ages, and progressing a certain distance may remain stationary for long periods; or undergo regressive atrophic changes. The treatment is much the same as in man, except that iridectomy is even more frequently followed by intraocular hemorrhage and other disasters, so that enucleation may be considered in preference. Elliot's operation (without iridectomy) is, however, worth trying and is certainly to be preferred to excision of the iris.

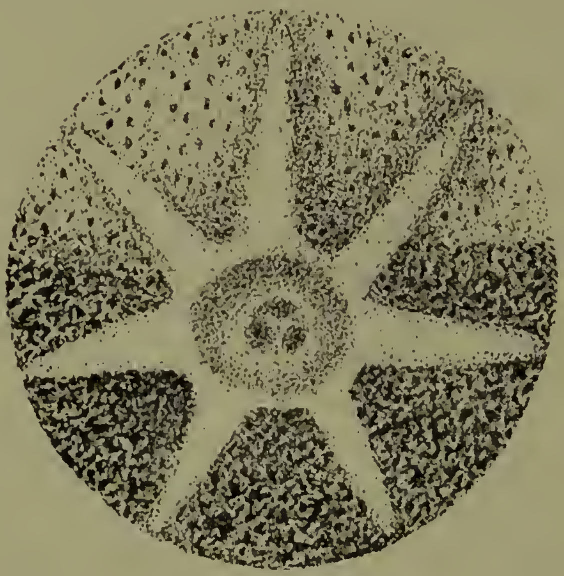
Diseases of the retina and optic nerve of animals.

A not uncommon form of *retinitis* is associated with diffuse choroiditis (q. v.). Pigmentary retinitis, however, of the human type is unknown in the lower animals. The majority of the retinitides are the result of infectious maladies, such as the so-called epizootic, petechial fever (horse), leukemia, male fern poisoning and wounds of the globe. Tuberculosis, as has been stated, accounts for *retinitis with hemorrhages,* followed by the white plaques seen in cattle. Nothing is known of retinal lesions in albuminuria and diabetes.

Detachment of the retina shows itself in the partial form as a peculiar lesion in the horse. In this animal the separation may assume the characters shown in the accompanying figure—yellowish-white, radial folds symmetrically placed about the papilla, their length being from one to two disc-diameters, and raised 1 to 2 mm. (one or two diopters) above the retinal plane.

In the dog, separation of the retina exhibits the same appearances as in man, beginning at the periphery, and may eventually become total, in wavy folds. In all these cases there is a vitreous involvement, generally the result of an iridocyclitis. The disease has been observed by Nicolas in the pigeon and the pig.

Tumors of the retina are very rare, although cysts have been reported as occurring in the ox, dog and horse; and retinal sarcoma in the horse.



Partial, Peripapillary Separation of the Retina in the Horse. (Nicolas.)

Retrobulbar neuritis has never been detected in animals, but *papilledema* (probably true *choked disk*) has been noted, due to causes similar to those found in the human subject—chief among them being cerebro-spinal meningitis (cattle) and hydrocephalus (horse). For example, brain tumor (sarcoma in the cat and horse), and cerebral hemorrhages (in the horse and dog) have been reported as a cause of choked disk.

Optic atrophy shows itself by the same signs and symptoms exhibited by man. It occurs in the lower animals as a consequence of optic inflammations, lesions of the brain and cord—cerebral softening, spontaneous (?) hemorrhages, fractures of the skull—as well as of extensive loss of blood, diseases of the heart, influenza, polyuria, etc. Eversbusch has recorded double optic atrophy as a *familial* disease, affecting a family of seven dogs.

Hyaline growths of the optic nerve have been described by Nicolas as occurring not uncommonly in the horse.

Cataract in the lower animals.

This subsection should be read in conjunction with the description given under **Comparative ophthalmology** of the various types of animal lenses, and their physiologic and anatomic relations.

Capsular cataract, especially the anterior polar variety, is very rare among the lower animals, although Bayer describes it in the horse as a congenital lesion. *Posterior polar cataract* is more common, as an opacity accompanying persistent hyaloid artery.

True *lenticular cataract* may be partial, may be limited to subcapsular areas or it may involve the whole lens. Bayer and Nicolas have described subcapsular opacities that were probably congenital. *Senile cataract* is rare in wild animals, if for no other reason than that they do not live long enough, but it is seen in the domestic class—dog, cat, caged birds. *Juvenile cataract* is often found in young dogs (Möller), during the first three years of life, and may affect only one eye. In these cases the cause is unknown, and the opacification may be complete in a few weeks. Diabetes is a cause of cataract in dogs. Iridocyclitis is by far the commonest cause of cataract in the herbivora—in horses especially—and it is often subcapsular. Traumatism is another common source of cataract.

Sulzer has described *epidemic cataract in fishes*—in the trout especially—due to penetration by the larva of a distoma found living in the interior of the lens. This parasite also pierces the eyeball or may provoke disorders leading to corneal perforation.

An interesting series of *familial cataract* is reported by C. P. Small (*Am. Journ. of Ophthalm.,* 1919), who observed four (and possibly five) members of one bovine family with congenital cataract in a valuable herd belonging to the Agricultural Department of the University of Illinois.

The treatment of animal cataract presents three operative methods, discission, extraction and reclination, but all these are, owing to intrinsic difficulties, and as a matter of experience, unfavorable to the animal. In all the larger domestics the retractor muscle and the third eye-lid (or its remains) present formidable obstacles to a successful outcome of most operative procedures. The employment of a speculum designed to elevate the latter has not proved of much use, while the pressure of the muscular contractions on the eyeball is often fatal in an attempted extraction.

In any event cocain anesthesia is insufficient and the operation must be done under general narcosis. It must be remembered, in this connection, that ether and chloroform anesthesia is particularly dangerous in dogs that have reached middle age and are affected by cardiac disease.

The large size of the lens (as compared to the human crystalline) must be borne in mind while making the corneal incision, which must be extensive, and an iridectomy is required to prevent prolapse of the iris. Even if the extraction wound heals nicely and without being infected, it is often followed by a whitish corneal infiltration that may persist indefinitely. Kalt (*Encyclopédie Française*) mentions two such instances in dogs which were also complicated with hemorrhage into the anterior chamber. He notes that Leblanc, in 1824, condemned extraction of cataract in the lower animals, having become discouraged by the occurrence of so many untoward accidents—iris prolapse, ectatic scars, hernia of the vitreous, intraocular bleeding and, not infrequently, loss of the eye. Hence he preferred reclination of the cataract. Berlin came to the same conclusion after many trials on the horse, and found that extraction was generally followed by atrophy of the globe; and his experiences with the dog were not much better.

Reclination of cataract in animals is more easily carried out than extraction, but this procedure may be accompanied or followed by intraocular hemorrhage (due to traction on the ciliary body) by separation of the retina and by iridocyclitis. Bayer recommends it (for cosmetic reasons) in eyes of horses destroyed by periodic fever, and Berlin finds it succeeds fairly well in dogs. Möller also favors depression in lower animal cataract. It is rarely followed by glaucoma.

When the animal is *young*, discission is to be preferred, as well as in all cases of soft cataract. The operation may be repeated a number of times; and if absorption does not take place reclination may be resorted to.

In the case of unusually docile and intelligent animals cataract glasses may be worn, and Suarez de Mondoza reports the case of a dog who used them with advantage!

The *technic of these three operations* closely resembles that followed in the human subject. Kalt believes that the horse requires chloroform while the dog may be given a preliminary hypodermic of 5 cgms. of morphia half an hour before the operation, which is then carried out under ether. In some small animals cocain alone may suffice.

After a discission it is better not to apply a bandage, although the animal's eye should be covered to prevent his rubbing the part—such as is elsewhere pictured in this section.

The steps both in reclination and extraction are as in man, except that in the latter operation an iridectomy is always indicated owing to the comparatively large size of the lens.

The *Ophthalmic Review* abstracts the following account, from the *Wochenschr. f. Ther. und Hygiene des Auges,* 1908, of the *extraction of a cataract from the eye of a rhinoceros* at the New York Zoological Gardens. The animal consumed 900 grammes of chloroform and 200 of ether before narcosis was sufficiently deep, and in the process several of the attendants were nearly overcome. Dr. Mater, Lecturer on Ophthalmology in the Veterinary College, was the operator, and the assistants included fourteen well-known surgeons and veterinary surgeons, six journalists, three photographers, and ten attendants from among the staff of the Gardens. One great difficulty which had to be contended with was to keep watch upon the heart of the unwieldy patient, for his skin was so thick that no pulse was perceptible by ordinary means. The operation lasted in all about half an hour, and was successful, we are given to understand, which is far from always being the case in the lower animals.

Dislocation of the lens following rupture, more or less complete, of the zonula, is not uncommon in the horse, after which (through the dilated pupil) can be seen the displaced margin of the crystalline. While this condition often results from traumatism yet in the herbivora it more frequently follows an iridocyclitis.

Diseases of the vitreous in the lower animals.

Vitreous hemorrhages are often noticed in horses during the course of an iridochoroiditis (*q. v.*). These deposits present the appearance of dust-like opacities, or they take the form of threads and membranes. Kalt believes they may be seen in from 10 to 15 per cent. of cases of equine iridochoroiditis. They should not be mistaken for the remains of the (congenital) hyaloid artery.

Synchysis scintillans has rarely been seen in the lower animals during life but the cholesterine crystals have been found *post mortem.*

Exophthalmos.

Some animals—like the King Charles spaniel—have normally very prominent eyeballs which are rendered more exophthalmic by disease, such as orbital tumors, cellulitis, etc. Terni has reported attacks of epidemic exophthalmos in fishes, the origin being an intestinal infection that eventually invaded all the tissues.

The vascular supply of the orbit in rabbits is so extensive and the veins anastomose so freely with the cavernous sinus, the internal jugular and the facial vein that the orbital contents are readily affected by infection from wounds of the head, neck, and face. Consequently these animals are especially subject to intermittent and other forms of exophthalmia—as Ulbrich has shown.

Exophthalmic goitre has been reported as occurring in the cow, the horse and the dog, with practically the same symptoms exhibited by man; and the treatment is the same.

Enophthalmus sometimes follows severe injuries to the globe.

Wounds of the eyeball, foreign bodies and *parasites* are much the same as in the human subject. Various species of filaria as well as the *cysticercus cellulosa* are the commonest of the last named.

Domestic fowls are subject to a purulent conjunctivitis due to a small white worm—*spiroptera mansoni*—that lives under the third eyelid and in the cul-de-sac; it infests also the nasal sinuses and neighboring cavities, but it does not enter the eyeball.

The *cysticercus* penetrates, as in man, the voluntary muscles—including those of the eye—as one development of hog measles.

The methods of *enucleation, evisceration* and *prothesis* are practically the same in lower animals as in the human subject. Bayer has imitated the appearance of the normal pupil, absent from the altered eye of a dog, by a subconjunctival injection of India ink. Trasbot recommends that the equine prothesis be made of gutta percha, should be ovoid in form, and should measure 45 mm. in its largest diameter.

Mouquet advises that the artificial eye in dogs be made of enamel, of glass or a combination of these. These protheses, in the case of all animals, should be removed for replacement once a day and cleansed.

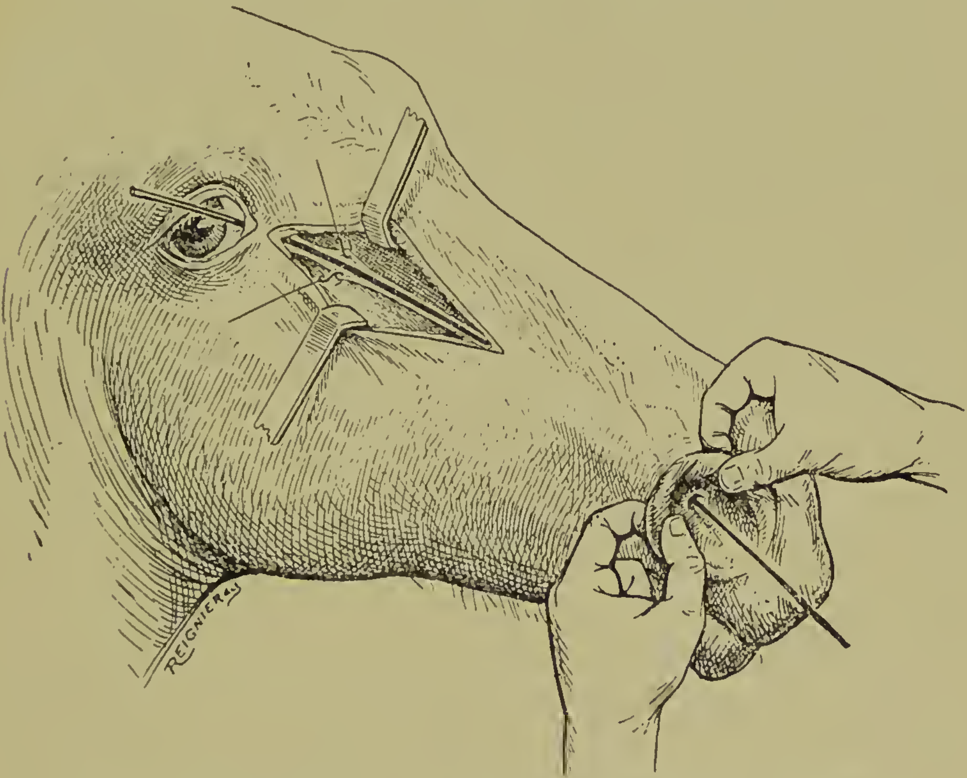
As a substitute for prothesis the lid edges may be joined by a tarsorraphy.

Ghisleni has employed the intraorbital injection of paraffin as an adjunct to, or a substitute for, the artificial eye.

Orbital affections in animals resemble closely those noted in man—wounds, injuries from foreign bodies, orbital cellulitis, metastatic inflammations, a large number of tumors, parasites, etc. The treatment of these pathologic conditions is about the same as in human subjects.

Lachrymal diseases in animals.

The student who would intelligently treat veterinary eye cases should be conversant with the anatomy and physiology of the organs under consideration. A study of the lachrymal apparatus in the various subclasses of the animal kingdom—especially of domestic animals—is essential to success in dealing with diseases of this rather complicated mechanism. The essentials of such a study are to be found under **Comparative ophthalmology** in this *Encyclopedia* and in monographs elsewhere. He will find that the *lachrymal gland* is 4 to 5 cm. long and 2 cm. broad in the horse, but that it is quite small in the dog and almost wanting in birds.



The Lachrymal Canal of the Horse. Passage of a Bougie. (Cadiot and Almy. *Encyclopédie Française.*)

The pathology of diseases of the tear passages is not well worked out in most of the lower animals. *Congenital dacryocystitis* is seen in chickens, accompanied by a mucopurulent conjunctivitis, and a compressible tumor near the canthus.

Acquired dacryocystitis is generally the result of dust infection of the conjunctiva and the resulting obstruction is generally at the lower part of the canal.

In the turkey it has been seen to occur epidemically, and may be followed by fistula. The lachrymal syringe is useful in the diagnosis and treatment of all these cases, and Nicholas has used one of 200 cc. in equine patients.

The use in the horse of the lachrymal sound in the form of a flexible catheter is illustrated in the accompanying figure. The canal in the horse is so sinuous that only such a soft rubber bougie (olive point preferred) can be employed that will adapt itself to the course of the canal. The instrument should be entered by way of the lower canaliculus and carefully passed into the nose.

Muscular anomalies in the lower animals.

Squint has been noticed in many families, especially of domestic animals. Probably, as in the case of man, domestication and civilization—a term that can be applied to many species of the so-called *lower* orders—tend to produce strabismus, which is extremely rare in wild races. At any rate this muscular anomaly has been recorded in the hen, the horse, the ox, the rabbit and the dog. In animals endowed with binocular vision (the dog, for example) it is easy to demonstrate a strabismic deviation of the eye, but this is not so easy in those animals with monocular vision only.

The pose of the head in paralytic cases is useful and often serves to indicate the character of the lesion.

A large Cartagena parrot in the National Zoological Park, Washington, furnished a good example of paralytic hypertropia in being obliged to elevate his mandibles high in the air to see objects much above the horizon. He had no lid paralysis and could see well objects on the ground.

The causes of paretic squint in animals are much the same as those in man. Of the causes of concomitant squint in the lower animals we know very little.

Nystagmus has been reported in the pig following botulism from eating pickled herring. It is occasionally a symptom in the horse of cerebrospinal meningitis and in the rabbit of cerebellar atrophy.

Vibratory massage. See p. 7612, Vol. X of this *Encyclopedia.*

Vibroscope. An instrument for observing, or registering, vibrations.

Vicarious menstruation through the palpebral skin is said to have occurred in a few instances but the authority for the statement is not very trustworthy.

Vidal, Auguste Théodore. A famous French surgeon and physician, of some importance in ophthalmology. Born Jan. 3, 1803, in the village of Cassis near Marseilles, France, he at first studied medicine in Marseilles, later, however, at Paris. At the latter institution he received his degree in 1828, presenting as dissertation "Nouveau Procédé pour Extraire les Calculs de la Vessie." Settling in Paris, he soon became collaborator on "*La Clinique*," "*Lancette*," "*Gazette Médicale*" and

"*Journ. Univ. Hebdomadaire.*" In 1832 he was made extraordinary professor of surgery, and in 1833 hospital surgeon. The full professorship he never reached. He was, however, a brilliant teacher, a dexterous operator, especially on the eye, and a brilliant and forceful writer. He died unexpectedly April 15, 1856, aged only 52 years.

Aside from his general writings, which are much the more important, he wrote two journal articles, one on lachrymal abscess, the other on the treatment of syphilitic iritis; which appeared in the "*Annales d'Oculistique,*" at p. 234 of Vol. XXIV, and p. 191 of Vol. XXXIV, respectively.—(T. H. S.)

Vidál, Domingo. An 18th century Spanish ophthalmologist, who, besides translating certain ophthalmologic writings from the German, wrote "*Tratado de las Enfermedades de los Ojos para Instruccion de los Alumnos del Real Colegiode Cirurgia de Barcelona, por el Licenciado Don Domingo Vidál, Bibliotecario y Maestro del Mismo Colegio*" (Barcelona, 1785).—(T. H. S.)

Vienna method. See **Enucleation of the eyeball,** p. 4414, Vol. VI of this *Encyclopedia.*

Vienna paste. A chemical escharotic made of caustic potash five parts, slacked lime six parts, with sufficient alcohol. This combination was to be applied to malignant growths.

Vierhügel. (G). Corpora quadrigemina.

Vierordt, Karl von. A famous German physiologist, who devoted considerable attention to the eye. Born July 1, 1818, at Lahr, in Baden, he received the medical degree in 1841 at Heidelberg, and settled in Karlsruhe. His only ophthalmologic publication was: "Beiträge zur Pathol. und Therapie des Strabismus" (*Heidel. Med. Annal.*). In 1849 he was called to the chair of Theoretic Medicine at Tübingen, and there he taught, wrote and practised until July, 1884, when he retired because of an affection of the heart. November 22, of the same year, he died.—(T. H. S.)

Vieusse's test for feigned blindness. See p. 1188, Vol. II of this *Encyclopedia.*

View. Examination by the eye; power of seeing, or limit of sight.

View-measurer. A device for measuring the dimensions of the image reflected on the sensitive plate.

View-telescope. An accessory telescope attached to a spectroscope.

Vina. See **Wines.**

Vincentiis, Carlo de. A celebrated Neapolitan ophthalmologist. Born at Naples Aug. 19, 1849, he received his medical degree in the University at that place. In 1877 he won, by competitive examination, the extraordinary professorship of ophthalmology at Palermo, and, ten years later, was called to the full professorship at Naples. In this last-named city he practised until his death, which occurred May 12, 1904. He wrote a large number of ophthalmologic articles, of which the most important are: *"Contribuzione all 'Anatomia Patologica dell' Occhio e suoi Annesi"* and *"Di un Raro Caso di Fibroma Papillare del Sacro Lacrymale."*—(T. H. S.)

Vincent's angina. Plant's angina. This is a non-febrile diphtheritic throat affection, in which there is acute ulceration with inflammation of one tonsil. It is caused by infection with the *Bacillus fusiformis.* The eyes are occasionally hyperemic. See, also, **Bacillus funduliformis.**

Vioform. Iodochloroxy quinolin. This agent is a coarse, yellowish, granular powder, odorless and of neutral reaction. It is used as a substitute for iodoform. The results of an experimental and clinical comparison of vioform with iodoform are reported by Beauvieux and Muratet. (*Archives d'Ophtalm.,* April, 1912.) They find that vioform is, at least, as effective a bactericide as iodoform, if not slightly superior. It gives as good results clinically in suppuration of the cornea, sclera, or lachrymal sac, and in suppurating wounds, as does iodoform. It has no odor, occasions no eruption, and is not toxic. The vioform should be reduced to a fine powder for use in ophthalmology.

The writers employed the two drugs in a series of 80 cases, consisting chiefly of infective lesions of the cornea, conjunctiva and lachrymal sac. Vioform was employed in fifty of these cases and iodoform in the remaining thirty. Seventeen cases of hypopyon keratitis were treated by vioform, and of this number the disease was arrested in fourteen instances; in three cases the eye was lost by panophthalmitis. Five cases of hypopyon keratitis were treated by iodoform. In all these the infective process was stopped and the eye saved.

Violaceous. Violet or purplish; blue, with a tinge of red.

Violet blindness. See **Yellow-blue blindness.**

Violet, The. *Viola odorata.* In ancient Greco-Roman times, a poultice of violets was often employed for acute inflammations of the eye accompanied by swelling and for exophthalmus. Instead of the plants, the roots were sometimes used, and these were commonly mixed with saffron and myrrh (q. v.).—(T. H. S.)

Violet vision. This phenomenon (see p. 2198, Vol. III of this *Encyclopedia*) occurs in both the toxic and the "genuine" chromatopsias. Knies has noticed it as a preliminary to the yellow vision of santonin poisoning. It has also been recorded as a symptom of cannabis indica intoxication; and from doses of carbon disulphide, *Anhalonium lewinii* and poisonous mushrooms; all of which are discussed under their own proper headings and under **Toxic amblyopia.**

Viol, Wilhelm. A Silesian ophthalmologist. Born at Ernsdorf, Apr. 7, 1817, he studied ophthalmology under Juengken, and in 1821 settled in Reichenbach. Here he founded the Silesian Association for the Treatment of Poor Eye-Patients. He was also a musician of some note. In 1847 he removed to Breslau, where he soon was known as an extremely skillful operator. He died at Breslau May 30, 1874.

Viol's more important ophthalmologic writings are as follows: 1. *Was hat man zu Thun, um die Augen des Neugeborenen Kindes vor Erblindung zu Bewahren,* etc. (Breslau, 1857.) 2. *Ueber die Gegenwärtige Verbreitung des Augencatarrhs.* (Breslau, 1861.) 3. Zur Casuistik der Intraoculären Geschwülste. (*Abhandl. der Schles. Gesellsch. für Vaterländ. Cultur,* 1861-62.) 4. Zur Modificirten Linearextraction Kernhaltiger Staarformen. (*Ibid.*)—(T. H. S.)

Virchow's corpuscle. Corneal corpuscle.

Virescence, VIRIDESCENCE. Greenness.

Virtual focus. A point behind a mirror or in front of a lens at which rays made divergent by reflection or refraction would meet if prolonged. See **Focus,** p. 5236, Vol. VII of this *Encyclopedia.*

Virtual image. An image apparent to the eye, but not capable of being reproduced on a screen, due to the imaginary prolongation of rays through a lens or a mirror. See p. 6175, Vol. VIII of this *Encyclopedia.*

Viscosity of the lens. This is a term applied by Lancaster and Williams (*Ophthalmoscope,* p. 112, March, 1915) to that physical condition of the crystalline lens that (among other effects) determines the rate of change in its shape during the accommodative act. The observers noted the fact that the lens is a markedly viscous body discovered in the course of some experiments on fatigue of accommodation. After a description of the experiments Lancaster and Williams assume, in attempting to interpret them, the substantial correctness of the Helmholtz theory of accommodation and of the observations of Hess and others on the relaxation of the zonule during strong accommodation, sometimes allowing the lens to move under the influence of gravity or of movements of the eyeball, and suggest that the events as they occurred in the person under observation be followed, viz., made to fix a test object at his near point, the subject contracts his ciliary muscle with vigor. The suspensory ligament is relaxed; the lens is no longer held in a partly flattened shape by the tension of these suspensory fibres on its capsule, it is free to take on its proper or natural shape and it does this. Whether it is by virtue of the elasticity of its fibres or other constituent parts, or whether the elastic impulse resides in the capsule or some other structure, it is not necessary to decide. The point is that the lens can take up the slack which would otherwise result from relaxing the zonule when the contraction of the ciliary muscle draws forward the posterior ends of the suspensory ligament. It is not able to take up all this slack under all circumstances, but, as is well known, when the lens becomes older, its capacity to change its shape, and so take up this slack, is diminished.

The fact that the ciliary muscle produces accommodation indirectly, and not by any direct action on the lens, is important in many ways. The eye is saved from the strain which would surely result in far greater degree with the onset of presbyopia, if by more forcibly contracting the ciliary muscle, direct pressure could be brought to bear on the lens, and so a bit more accommodation could be squeezed out of it, so to speak. Instead of this, all we can do is to relax the zonule, and let the lens do what it will to change its shape. More powerful contraction of the ciliary muscle is fruitless, since it merely so slackens the zonule as to allow the lens to sag or sink under the influence of gravity. But how about the increase of accommodation and approach of the p.p. so often observed after eserin? Hess explains this as only an apparent, not a real approach of the p.p. He says that it seems to the subject being tested that his p.p. is nearer; this is only because his pupil is so much smaller, and therefore the circles of diffusion are so small that he thinks his p.p. is nearer than it really is.

This is where Hess and his pupils left the problem. Proceeding a step farther—if after the suspensory ligament is fully relaxed, any increase of the accommodation takes place, so that the p.p. comes appreciably nearer, it must be because the lens continues to grow more strongly refractive, doubtless more convex. This change in shape is due to elasticity; the slowness of its change is due to what may be called *viscosity*.

The approach of the p.p. caused by eserin is of this same nature. The ingenious explanation of Hess falls down when applied to these experiments, where no miotic is used. The change in the size of the pupils is only the small change which goes with accommodation and convergence, and occurs at once on focussing for the near point, not gradually in the course of several minutes as does the approach of the near point in these experiments. The experiments show that when the zonule is relaxed there is an initial change which occurs quickly (less than a second), but that the change does not stop there; rather the lens continues to become more convex, though at a slower and slower rate. The idea is that the force which brings about the increased convexity of the lens is opposed by another force which it overcomes only gradually. There is a time element. We call the first force the elasticity of the lens, capsule, etc.: for the second the writers named suggest the term viscosity, for the time element is the essence of viscosity.

Vis de rappel. (F.) Focussing screw.

Visibility. The state of being visible; the quality of being perceivable by the eye.

Vision. EYESIGHT. The act of seeing, that faculty of the mind by means of which, through its appropriate material organ, the eye, we perceive the visible appearances of the external world. Vision is mainly concerned with the color, form, distance, and tridimensional extension of objects. It is caused by impact of ether-waves on the retina of the eye; but if these waves be longer or shorter than a certain limit there is no visual impression produced by them. The apparent color of an object depends partly on the wave-length or wave-lengths of the incident light-waves, single or mixed, and partly upon the state of the eye itself, as in color-blindness, or after taking santonin, which makes external objects look yellow, or in jaundice. The apparent brightness of an object depends upon the amplitude of the light-waves which pass from it to the eye; and the smallest perceptible difference of brightness always bears a nearly constant ratio to the full intensity of the bright objects (Fechner's psychophysical law, see p. 5176, Vol. VII). As between different colors, the eye perceives them with different intensities even when the physical intensity is the same: thus yellow appears brighter in a bright light than an equally intense red: and as light fades away the different colors fade away unequally, so that the ratio in Fechner's law above referred to is different for each color; red and yellow disappear first, blue last; and thus in a dim light the blue is the brightest. (*Standard Encyclopedia.*) See, also, **Acuteness of vision**; as well as **Light**; and under **Physiological optics.**

M. Tscherning (*Scientific American Supplement*, May 31, 1913) constructs a theory based on assuming an analogy between the "fixation point" which he calls the "principal element" of the retina from which proceeds a luminous pencil of light, and a "photophore," a sort of surgeon's probe—with which the visual organ explores the world just as an operator does a cavity or wound. He says that the superiority of vision lies chiefly in the fact that we possess an enormous number of retinal elements, and therefore an enormous number of photophores, proceeding in all directions from the pupil. The accessory photophores can give us information concerning the form of external objects; but their chief task consists in directing our attention to one of the luminous points, which we then fix upon. We should thus have to imagine the eye provided with an invisible, cone-shaped apparatus, whose vertex is the pupil, and whose base is a sensitive mosaic, the outer image (clear or diffused) of the retina. This mosaic, which he calls the "apparent retina," has the shape of the totality of objects visible at any one time. It molds itself on them, as it were. A moment afterward the direction of the eye changes, and the terminal surface changes, and so on. As the surgeon constantly moves the probe, we move the eye to explore the external world.

Vision, Achromatic. Vision marked by complete loss of the color sense; total color-blindness.

Vision, Binocular. See p. 973, Vol. II of this *Encyclopedia;* also under **Stereoscope.**

Vision, Black. See p. 1007, Vol. II of this *Encyclopedia,* as well as under **Chromatopsias.**

Vision, Blue. CYANOPSIA. See **Blue vision,** p. 1238, Vol. II, and under **Chromatopsias,** of this *Encyclopedia.*

Vision, Blue-green. See **Blue-green vision,** p. 1236, Vol. II of this *Encyclopedia.*

Vision, Center for. In addition to the observations on p. 6547, Vol. IX, and p. 1953, Vol. III of this *Encyclopedia,* it may be said that after a study of 2000 cases of war injuries of the brain, Lister and Holmes (*Oph. Year-Book,* p. 257, 1916) never saw a central scotoma when direct injury of the occipital lobes could be excluded and they regard this as striking evidence that central vision is represented on either or both the mesial or the lateral surface of the posterior borders of the occipital lobes. The observations conform to the general view that the visual area corresponds with, or at least includes, the area striata.

The authors' conclusions (which they do not regard as final in view of the short lapse of time), are as follows: (1) The upper half of each retina is represented in the dorsal and the lower in the ventral part of each visual area. (2) The center for macular vision lies in the posterior extremities of the visual areas, probably on the margins and lateral surfaces of the occipital lobes. (3) That portion of each upper quadrant of the retina in the immediate neighborhood of and including the adjacent part of the fovea centralis is represented in the upper and posterior part of the visual area in the opposite hemisphere, and vice versa; (4) The center for vision from the periphery of the retina is probably situated in the anterior end of the visual area, and the serial concentric zones of the retina from the macula to the periphery are probably represented in this order from behind forwards in the visual area.

Beauvieux, *Archiv. d'Ophtal.,* 1918, p. 410, as a result of his studies of wounds of the visual sphere, is satisfied that the visual cortical zone is localized in the posterior part of the brain, in the occipital region; this zone being apparently limited to the internal surface of the occipital lobe, the calcarine fissure, and the superior and inferior margins of this fissure. The external surface of the occipital lobes does not form a part of the cortical centers of vision. The grouping of the fibers is in quadrants, the fibers being placed in the same order as in the retina, with isolated conduction for the superior or inferior quarters of each retina.

According to this anatomic conception, circular hemianopic scotomata can be explained only by a symmetric and bilateral disturbance of the radiations with special grouping of the nerve bundles innervating a circular retinal zone, or by destruction of fibers of association uniting by the intermediary of the corpus callosum two identical portions of the visual centers, or finally by a purely functional syndrome without a true lesion of the optic tracts. The circular bundle does not appear to Beauvieux to have a precise and circumscribed localization at the level of the calcarine fissure. The macular fibers seem rather to radiate in a fan over the whole visual cortical surface.

Vision, Colored. See **Chromatopsias**; as well as **Colored vision**; also, *colored vision after cataract extraction,* p. 1745, Vol. III of this *Encyclopedia.*

Vision, Conscious. See **Conscious vision,** p. 3184, Vol. V of this *Encyclopedia.*

Vision, Depraved. See **Dysopia,** p. 4107, Vol. VI of this *Encyclopedia.*

Vision, Direct. Central vision; that seen with the fovea.

Vision, Eccentric. PERIPHERAL VISION. Perception of objects by the retinal or optic fibres distributed outside the macular region.

Vision, Facial. The power of judging (especially by the blind) of the distance, direction, etc., of objects by the sensation felt in the skin of the face. See p. 1203, Vol. II of this *Encyclopedia.*

Vision, Field of. See **Perimetry.**

Vision, Green. See **Chloropsia,** p. 2068, Vol. III of this *Encyclopedia.* also under **Chromatopsias.**

Vision, Indirect. See **Vision of eccentric.**

Vision, Inverted. See **Upright vision**; as well as **Mirror-writing**; and **Inversion of the image,** p. 6560, Vol. IX of this *Ecyclopedia.*

Vision, Iridescent. See p. 6595, Vol. IX of this *Encyclopedia.*

Vision, Learning of. See **Learning of vision,** p. 7028, Vol. IX of this *Encyclopedia.*

Vision of motor drivers. VISUAL REQUIREMENTS OF AUTO DRIVERS. The visual requirements of chauffeurs, etc., vary greatly from town to town throughout the world. In an effort to standardize the regulation of motormen a committee (see *Br. Journ. of Ophthalm.*, March, 1919) has been appointed by the Council of British Ophthalmologists to report on the visual requirements desirable for those who are granted licenses to drive various classes of motor vehicles. A questionnaire on the subject has been submitted to ophthalmic surgeons in Great Britain.

See, also, **Chauffeurs, Vision of,** p. 2026, Vol. III, and **Automobile drivers, Vision of,** p. 710, Vol. I of this *Encyclopedia*.

Vision, Parafoveal. This, the most distinct vision outside the fovea, forms the subject of important studies made in the Laboratory of Physiology, Leland Stanford University. A comparison of foveal and parafoveal vision by strong and feeble light, is given by Daizo Ogata and Frank Weymouth (*Amer. Jour. Ophthal.*, p. 750, 1918).

The suggestion for the present work came from an observation of one of the authors that glasses which satisfactorily corrected his hyperopia in the daylight proved too strong, that is, "over-corrected," in the evening when out of doors, often to such an extent that they were discarded. This has since been confirmed in several other hyperopes.

An attempt was therefore made to determine the nature and extent of this difference under experimental conditions admitting of satisfactory control, and should such a difference be clearly proven, to explain it on the basis of the known structure of the eye or of changes hitherto assumed to take place in it.

The first experiments were concerned with a comparison of the refraction in foveal vision in the light and in the dark-adapted eye. Since it was soon apparent that these showed no striking differences the work was extended to a comparison of the refraction in the regions near the fovea (parafoveal vision) since it was known that these are used in twilight vision. The data thus obtained permitted the comparison between foveal and parafoveal vision both light and dark-adapted.

From these experiments the writers draw the following conclusions:

Small differences of refraction between foveal vision in the light and in the dark, and between parafoveal vision in the light and in the dark, are shown by from 10 per cent. to 20 per cent. of the reagents examined.

A definite refractive difference between foveal and parafoveal vision is shown by from 40 per cent. to 45 per cent. of the reagents. The difference between the fovea and a spot 5° eccentric (temporally) from it, amounts to from .33 D to .50 D, the parafoveal region being more myopic or less hyperopic than the fovea.

The observation that glasses suitable in bright light become less so in dim light accords with the facts established.

These facts have a practical application in the correction of refractive errors. Care should be taken in those cases in which the person must distinguish signals in dim light (railway engineers, firemen, signalmen, ship's lookouts, etc.) to see that the glasses given are suitable for twilight vision, as in a certain percentage of cases the correction under ordinary conditions is distinctly different from that in dim lights.

A possible explanation is offered by the present facts for the differences found between the refraction as determined by the retinoscope and by subjective methods under otherwise similar conditions.

The differences found between foveal vision in the light and in the dark or parafoveal vision in the light and in the dark seem to be best explained by Jackson's theory of the influence of the widened pupil in the dark adapted eye in admitting the peripheral, more strongly refracted rays.

The difference between foveal and parafoveal vision does not seem to the authors to be due to optical factors affecting the incident light in the two cases, but is more satisfactorily explained by the assumption that the membrana limitans externa bulges outward (away from the vitreous) in one, two, three or all directions from the fovea. In the latter case the conditions are those which have been described by histologists as an external fovea.

Vision, Perspective. See **Stereoscopic vision.**

Vision, Red. See **Erythropsia,** p. 4519, Vol. VI, as well as under **Chromatopsias,** in this *Encyclopedia.*

Vision, Solid. STEREOSCOPIC VISION. Perception of the relief of objects or of their depth; that in which objects seen appear as solid objects, and not as flat pictures. See **Stereoscope.**

Vision, Starlight. See **Starlight.**

Vision, Stereoscopic. See **Vision, Solid,** and under **Stereoscope.**

Vision, Telescopic. See **Tubular vision.**

Vision, Tests for. See **Examination of the eye.**

Vision, Twilight. See **Twilight.**

Vision, Upright. See **Upright vision**; as well as p. 6560, Vol. IX of this *Encyclopedia.*

Vision, Violet. See **Violet vision.**

Vis micrométrique. (F.) Micrometer screw.

Vision, Word. A special function of the general visual center.

Vision, Yellow. See **Xanthopsia**; as well as **Colored vision** and **Chromatopsias.**

Visual. Of, or pertaining to, or resulting from, the sense of sight.

Visual acuity. See **Acuteness of vision,** p. 88, Vol. I; also **Examination of the eye,** p. 4640, Vol. VI, **Chart, Visual test;** and p. 2016, Vol. III of this *Encyclopedia.*

In addition to the matter found there it may be said here that David E. Rice (*Archives of Psychology,* Feb., 1912) has investigated and tested the *visual acuity with lights of different colors and intensities.* He believes (1) that as regards the relation of acuity to intensity, it is shown that with uncolored illumination approximately 75 per cent. of daylight acuity is attained with an intensity of from 8 to 10 meter-candles; with a reduction of intensity below this point the acuity decreases rapidly, and with an increase of intensity beyond this point the acuity rises very slowly, unit acuity being attained with an intensity of from 40 to 50 meter-candles. As in daylight vision, after unit acuity is attained, further increase of intensity shows practically no gain in acuity. It may therefore be considered that intensities of 8 and 40 meter-candles constitute approximately the lower and upper limits, respectively, of suitable illumination for ordinary purposes. 2. As to the relative efficiency of red and green or blue illumination, the advantage lies decidedly with the red. Monochromatic yellow does not enter into this comparison. So-called white illumination gives a slightly higher acuity than red, but inasmuch as white illumination is predominantly yellow, it is quite possible that monochromatic yellow would have the same influence on acuity as white. 3. A probable explanation of the greater efficiency of red illumination is to be found in the apparently greater sensitivity of the form-perceiving end-organs, the cones, to light of longer wave-length, as compared with the brightness-perceiving elements, the rods, which have been shown to be more sensitive to the shorter wave-lengths. 4. In the study of visual acuity many distinct factors are involved, failure to regard any of which will seriously affect the results obtained. Among these the most important are: (a) Photometric determinations. Accurate estimation of relative intensities of colored illumination by direct methods is exceedingly difficult, if not impossible, and the flicker method is proposed as the only satisfactory one for making heterochromatic comparisons; (b) Test-characters. Care should be taken that the test-character employed actually measures the form-sense rather than the brightness-sense, and that it involves the use of the eye under conditions approximately similar to those under which the latter is commonly used; (c) Individual differences. The demonstrated existence of great individual variations makes it imperative that the visual peculiarities of any observer be definitely determined. Value can attach only to results which represent the average of a number of observers.

E. Landolt (*Archives d'Ophalm.*, July-Aug., 1916; abstract in the *Br. Journ. of Ophthalm*, p. 108, Feb., 1917) recently points out the importance of more accurate methods of recording *near visual acuity.* He defines the usual methods of measuring the visual acuity *for distance* as the "practical distant visual acuity." However, in this the possible effect of glasses in diminishing or increasing the size of the retinal images is neglected. The determination of the form perception of a given retina, i. e, the least separation that two luminous points must have to be seen separately, which Landolt defines as the "physiological visual acuity," can be arrived at indirectly only by calculation of the effect of correcting glasses on the size of the images that fall on the retina. If we assume that the error of refraction is entirely due to differences in length, axial ametropia, the retinal images would be unaffected in size by correcting glasses at 13 mm. from the eye. On the other hand, if all the eyes were of the same length, the correcting glasses would have to be in contact with the cornea to leave the size of the retinal images the same. As it is obviously impossible to determine ,for any given eye, how much of the ametropia is due to length and how much to altered curvature, refractive power, and position of the crystalline, direct determination of the physiological visual acuity cannot be made. We do, however, know that the greater part of any metropia is due, as a rule, to axial change, and may safely conclude that, with the exception of aphakic eyes, the influence of correcting glasses on the size of retinal images from distant sources may be neglected.

Landolt concludes that the usual way of stating the visual acuity of those whose work is distant is sufficiently accurate, but to secure accurate adaptation for *near work,* one of three things must be done: either the accommodation must be employed, or a *plus* glass added, or a *minus* glass removed. The effect on the size of the retinal images differs with the method of accommodation used. Theoretically, it is possible to calculate the near from the distant visual acuity, but not so practically, as we are unable to measure the length and refractive power of an individual eye under the given conditions.

In order to test *near visual acuity,* Landolt has a series of optotypes calculated for the following visual acuities: V0.1; 0.15; 0.2; 0.3; 0.4; 0.5; 0.6; 0.7; 0.8; 1; 1.5; 2. If they are used at other distances than that for which they are marked, a calculation has to be made.

If V is the visual acuity marked on the type for distance D, then v is the visual acuity for another distance d measured in metres.

$$\text{Then } v=\frac{Vd}{1/3}=3\,Vd$$

Owing to the war, Landolt was not able to have more than a few of his types made, but has found some interesting results from his experiments with them. Thus, he has found that in high myopes the visual acuity for near vision may be double that obtainable for distant vision.

He is also of the opinion that some practical value attaches to the results obtained in the calculation of compensation for injuries.

The makers of the *Ives visual test object* (see cuts) claim that the instrument overcomes some of the defects of the common alphabetic test charts in the scientific measurement of visual acuity. Those charts are faulty in that the transition from one size of detail to another is abrupt instead of continuous; that all the letters of one size are not equally difficult of recognition; that children and illiterates cannot be tested. Furthermore, the judgment of the patient may be influenced by the knowledge of the change of distance or power of light. Letters and figures of the same size but different shapes, as for instance the letters R, B and I, or figures 0, 3, 8, etc., furnish different results at a given distance and variable illumination.

As a consequence of the capacity for continuous, instead of abrupt, change of the size of detail, the instrument can be callibrated to read acuity directly in decimal fractions of the unity of any required degree of delicacy. The instrument lends itself admirably to the determination of the axis of astigmatism, as well as to acuity determinations.

The essential part of the apparatus consists of two opaque line gratings, whose lines are too closely ruled to be separable by the eye at ordinary working distances. These gratings are laid one over the other and are arranged to turn with respect to each other on an axis perpendicular to their faces. When two such gratings ruled with parallel straight lines in one direction only are so turned, there result parallel bands of opacity and transparency, many times as wide apart as the original ruling whose actual separation varies inversely with the angle of rotation of the gratings. If the gratings are ruled with two sets of lines at right angles, the effect, when they are turned with respect to each other, is the production of a pattern of squares, whose size also varies continuously and inversely with the angle through which the gratings are turned.

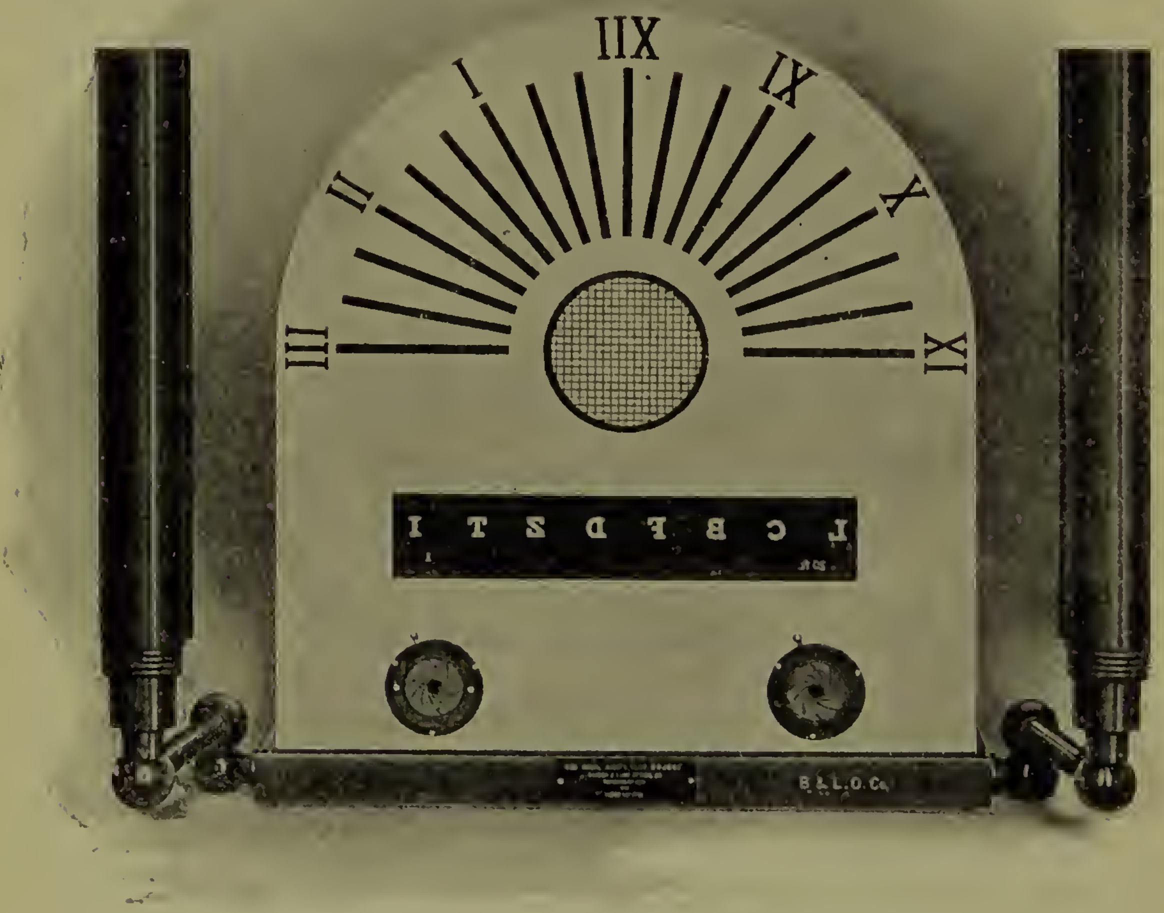
The visual acuity is measured by the smallest separation of the bands or the smallest size of the squares, as the case may be, which is just perceptible to the eye. When that point is reached, any further increase in the angle between the two sets of rulings will cause the whole surface to appear uniformly gray to the patient. Since the size of detail of the pattern depends on the angle between the two sets of rulings, whose separation is known, viz. 60 to the inch, the angle may be made the measure of the acuity and a scale may be provided, from which visual acuities are read directly.

The apparatus as constructed and shown in the illustrations (front and back views) consist of a grating holder, a housing for the electric lamp, which provides the illumination for the gratings, and a front plate, which provides the surrounding field and is utilized as well to carry various other objects for visual testing, as, for instance, a lamp with iris diaphragm for muscle testing, special colored screen for chromatic test, lamp fitted with iris diaphragm and color screens for railway signal tests, and smoked glass wedge by means of which the effect of the colors may be dimmed or brightened as the case may be. The upper half of this front plate is provided with an astigmatic chart consisting of a series of single lines with a space of 10° between each two lines. This astigmatic chart is numbered in the clock-dial fashion to facilitate the reading.

Just below this astigmatic chart in the center of the front plate, a circular aperture of 3-inch diameter is provided, through which the Ives test object is to be seen. Just below this central aperture the front plate is provided with an oblong aperture behind which two rollers are mounted, carrying a set of Snellen test types so arranged that only one row of the test type is visible through the oblong aperture at one time. The test type is white on black background, and three rows of each size of letters are provided, the letters being different in each row in order to prevent memorizing. The Snellen test type serves the purpose of checking up the result obtained with the Ives test object. Additional lamps are provided for the illumination of the entire front plate and its auxiliaries.

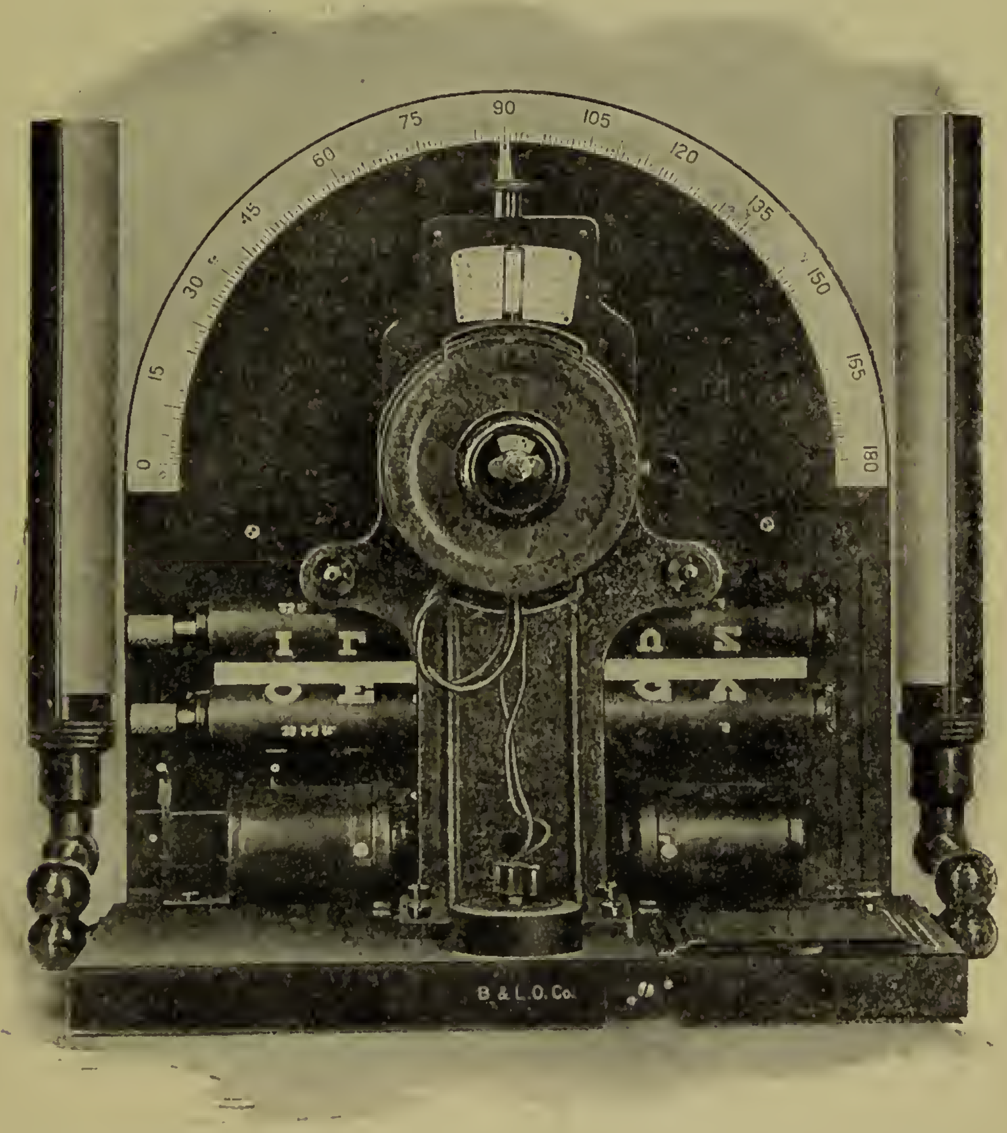
The grating holder of the Ives acuity test object proper is mounted behind the front plate and carries two gratings, so arranged that they may be rotated in opposite directions to each other by means of a rack and pinion movement, manipulated by turning the milled head on the pinion. One of the gratings is made removable so that either the single line or the cross line grating, both of which are supplied with the instrument, may be inserted with their consequent line or square pattern. The acuity scale is mounted just below the milled head of the rack and pinion movement and reads directly in Snellen acuity units; that is, unit acuity corresponds to the detection of the separation of lines or bands whose centers are two minutes of arc apart. This is the 5/5 or 6/6 of ordinary terminology. The ordinary 6/12 or 5/10 read as .5, etc.

The scale is marked at the side meters of reading distance, indicating which line of the scale is to be used for any chosen distance between observer and test object. The zero of the acuity scale is the point where the lines become of infinite width as viewed from a considerable distance, or where they turn over as viewed from nearby. The pointer is provided with an adjustment to correct the zero in case of shift.



Ives Visual Acuity Test Object. (Front view.)

The grating holders, together with rack and pinion arrangement, may be rotated about its axis so that the lines or squares stand at various angles with the horizontal. The angle, at which the bands produced by the single line grating stand, is indicated by the pointer on the scale of degrees on the back of the front plate. The operation of measuring visual acuity is very simple. The gratings are turned so that the bands or squares are too small to be visible to the observer. They are then rotated slowly by means of the rack and pinion movement until the observer just sees the pattern, whereupon the acuity is read from the scale. As a check on the correctness of his observation, the patient may be asked in which direction the lines lie, and this direction may be changed between observations so that he is in ignorance which way to expect them.



Ives Visual Acuity Test Object. (Rear view.)

Either the lines or the squares may be used for acuity testing as preferred. For finding the axis of astigmatism the lines are preferable.

The gratings are to be set so that the bands are just visible and then rotated together in their holder until the bands appear clearest, when the corresponding angle is read from the scale marked on the back of the front plate.

The apparatus is furnished with tungsten electric limo lamps fitted with special blue glass filters to transform the light into average daylight color. As it is desirable to operate the apparatus from the position of the patient, and to shorten the distance between test object and patient by using a mirror, the clock-dial figures for astigmatic chart, Snellen test type, and other features on the front plate are reversed so as to appear correct when seen in the mirror. A first surface mirror of suitable size, mounted in metal frame with metal cover for protection, is furnished to order.

For *testing malingerers* a set of colored disks may be supplied and used in front of the lamp for the muscle test. The colors, red, green and blue are then readily available and any other may be substituted. The apparatus is made entirely of metal, with the front plate enamelled so that it can readily be cleaned with a moist sponge.

Visual agnosia. Disturbances or loss of the power to identify objects by means of the eyesight.

Visual agraphia. OPTIC AGRAPHIA. A form of the disease in which the patient cannot copy writing but can write from dictation. See, also, p. 9057, Vol. XII of this *Encyclopedia.*

Visual amnesia. MIND BLINDNESS. VISUAL APHASIA. OBJECT BLINDNESS. See p. 1131, Vol. II of this *Encyclopedia.*

Visual angle. The angle which is included between lines drawn from the extremities of any object to the first nodal point of the eye.

Visual anomia. WORD DUMBNESS. MEMORY-LOSS. See **Memory, Visual,** p. 7639, Vol. X of this *Encyclopedia.* Anomia is the loss of the power to name objects or to recognize names, and is a form of *visual aphasia* (q. v.) often included under *mind-blindness.* It is caused by lesions of the speech-center. See p. 1131, Vol. II of this *Encyclopedia.*

Visual aphasia includes all those abnormalities of speech and writing that result from alterations in the visual centres concerned with language, as well as with the tract associating these centres with other higher and lower brain areas and centres. Mills (*The Eye and Nervous System,* p. 114) says that the "most important varieties of visual aphasia and allied disorders are: (1) mind- or object-blindness; (2) word-blindness; (3) letter-blindness; (4) visual agraphia; paragraphia and dysgraphia; (5) optic aphasia or word-dumbness.

"Some objection might be made to including mind-blindness in the category of visual aphasias, and such objection is doubtless valid, but as a matter of convenience and with some scientific basis, I have thought it well to include mind-blindness under the general head of visual aphasias. The patient who is unable through sight to recognize a familiar person or object, or to recall the visual memories of such person or object, cannot of course name that of which he is not cognizant, and hence is aphasic in this indirect sense. Psychic blindness is, however, a disorder distinct in most persons from visual aphasia, and it will be therefore understood that it is only included here because of convenience, and because it is so frequently associated with the true cerebral sensory disorders of speech."

See **Visual anomia,** as well as **Optical aphasia,** p. 9057, Vol. XII of this *Encyclopedia.*

Visual apparatus. The eye and its appendages.

Visual area. See **Centers, Visual,** p. 1953, Vol. III of this *Encyclopedia.*

Visual attention. See under **Visual space perception.**

Visual aura. An aura (or premonitory sign) consisting of some visual hallucination, as in migraine.

Visual axis. VISUAL LINE. The straight line passing through the centre of the pupil to the macula lutea. It makes an angle of 5° with the optical axis.

Visual centers. See **Vision, Center for.**

Visual centers, Injuries of the. The *optic radiations,* in their journey from the basal ganglia to the occipital lobe, pass slightly below the cortex of the angle gyrus, and are easily cut or compressed by changes affecting the latter. The cortical sphere has to do with both luminous sensation and natural vision. Conceptions of form, space, locality, and of orientation are herewith determined, perhaps with the aid of other centers which are not yet estimated.

Blindness may be limited to colors, or to both white light and colors and may be partial or complete for either.

There is a difference between the physical and psychical image. The image may be properly formed on the retina and carried to the visual sphere without the latter perceiving it through suppression of the receptive apparatus. There may also be loss of correlation of the several centers connecting with the visual sphere, especially that of language, causing verbal blindness.

Therefore, in discussing the pathologic anatomy and physiology of vision, we should distinguish (1) physical blindness, the physical interruption of the recipient and carrying portions of the ocular apparatus; i. e., the eyeball and nerve tracts. (2) Cortical blindness, equivalent to the loss of luminous sensation. (3) Psychical, equivalent to the loss of commemorative images of objects. (4) Verbal blindness, implying the loss of power of reading words or signs. This last variety is a form of aphasia.

Injuries to the brain may cause various kinds of aphasia, of which a unique form is that of *ideographic blindness.*

The area of language is located in the lateral cortex, reaching from the first and second frontal convolutions, where the center of the motor images or the articulation or center of Broca exists, backwards along the upper part of the temporal lobe where, immediately below the Sylvian fissure in the ascending parietal convolutions is located the center of the auditory images of words, or center of Wernicke. Farther back, at the end of the parieto-occipital fissure is located the center of the visual images of words.

Broca's center is in contact with the general motor area, the center for auditory images is almost identical with that of general audition. The center for visual images is connected with the center of general vision by its deep surface, and comes in contact with the optic radiations, which proceed from the internal surface of the posterior portion of the occipital lobe, especially including the cuneus and a portion of the lingual lobe, the two convolutions forming the boundary of the calcarine fissure. The ideographic or writing center is now located by example and by deductions from the observations of other authors, in the upper part of the third frontal convolution. Disturbances of any of the so-called centers of the visual sphere, or the radiations proceeding between them, cause distinct clinical manifestations which cannot be entered into here.

Blindness and *ocular palsies* following violent injuries of the face and head, not only are due to both *direct and indirect injuries to the optic and oculomotor nerves,* but also the cerebral centers. A number of cases are on record of immediate and permanent blindness after the injury, followed in some weeks by signs of atrophy, due to central injury. Rarely there may be a recovery of some vision, even with a white disc and contracted fields.

Medico-legal reports of accidents occurring to persons working in various industries should of necessity be exact as to the determination of the etiology and prognosis of certain visual troubles, such as amblyopia and amaurosis following traumatism of the head.

Many cases of *amaurosis* follow, as is well known, *a blow on the head,* of which the pathogeny is indirect fracture through the optic canal, or an effusion of blood in the nerve sheath. But more frequently is it the case where, following a trauma of the cranium, the injured person, in good faith or not, claims the visual loss to be due to the injury, while the lessened vision may have existed prior to the accident.

There is differentiation to be made between central injuries, those due to damage to the visual sphere, those to the conducting apparatus, the optic nerve and to the peripheral end of the optic apparatus, the retina and other parts of the eyeball.—(H. V. W.)

See, in this connection, **Vision, Center of**; **Gunshot injuries**; **Military surgery of the eye**, the various **War** captions, also **Visual economics.**

Visual cone. A cone, the vertex of which is at the eye, the marginal lines touching the boundaries of a visible object.

Visual cortical center. See **Vision, Center of.**

Visual economics. THE COMMERCIAL VALUE OF INDUSTRIAL VISION. MONEY COMPENSATION FOR LOSS OF SIGHT IN INDUSTRY AND THE TRADES. WORKMEN'S COMPENSATION FOR DAMAGED OR LOST VISION. [Authorities by no means agree as to the feasibility or possibility of estimating by means of mathematical formulæ the money compensation to be paid a wage-earner who, while in pursuit of his occupation, sustains material damage to one or both eyes. The writer of the main body of this section believes with Magnus, Würdemann and others that it can be done; other observers of equal experience and authority are of the opinion that definite, mathematical conclusions are not always forthcoming, and that equitable judgments must necessarily consider factors that are in their very nature variable.—Editor.]

INTRODUCTION

[1] Visual economics is an important part of physical economics which treats of the functions of the body solely for the purpose of determining the true state of the earning ability of a person and its percentage of loss, upon which compensation must always be based.

[2] The functions of the eyes are in such intimate relationship, physiologically, with the functions of the different systems and organs of the body that they cannot be considered independently, either as to their inherent functions, or as to their earning ability; and any method which would undertake to determine the loss to the earning ability of a person from loss to the functions of the eyes, which could not be used at the same time and in a similar manner to determine conjointly the loss to the earning ability of a person from loss to the functions of any other organ of the body, which might have been caused by the same injury or disease, would be, from the very nature of the case, an empirical method.

[3] In order to determine the loss to the earning ability of the body from the loss to the functions of the eyes from injury or disease, we must adopt the only method by which these physiological relation-

ships can be maintained, just as really they are in nature. We must, therefore, adopt the natural science method, by which the functions of the eyes can be considered just as really they are, namely, an important part of the whole functional ability of the body, and therefore an important part of the earning ability of the whole body.

[4] The determination of the loss to the earning ability by the natural science method as employed in physical economics is as follows: The standard of measurement for the loss of the function of vision of one eye is .18[*] of F, the functional ability of the whole body. This is subtracted from 1. and .82 is obtained for the coefficient of F (.82F) (for the multiplicand). As C, the competing ability of a person (the multiplier in this case) depends upon the same identical functions of the structures of the body, its primary coefficient must be the same as that of F, the functional ability of the body. Hence this statement in the natural science formula is as follows: $.82F\ .82C = E$. The next step in the solution of this problem is the determination of the damage to C, the competing ability, whether this factor (the multiplier) shall remain as in the statement of the earning ability in the formula, or whether it shall be decreased in order to give a greater loss to the earning ability, as follows:

$.82F\ .82C = E$. Hence $E = .6724$, and the loss is .3276

$.82F\ .82C^2 = E$. Hence $E = .5513$, and the loss is .4487

or whether it shall be increased to give a lesser loss to the earning ability, as follows:

$.82F\ .82C = E$. Hence $E = .6724$, and the loss is .3276

$.82F\ .82C^{1/2} = E$. Hence $E = .7429$, and the loss is .2571

[5] The natural science method is the only method known to physicists by which the value of any physical force can be determined, or to economists, by which the value of any commodity can be ob-

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[*] The standard of measurement for the economic loss to the whole functional ability of the body for the loss of the functions of one eye to 20/200 (0.1) or less, according to the scientific standard of measurement, which by common consent has been accepted for the economic standard of measurement, may be obtained: First; from a compilation of all the accessible values given for this loss and then dividing the sum total by the number thus compiled. By this means we obtain a quotient that is nearer to .18 than that of any other number. (The value obtained from the solution of the formula of Magnus is .175. Vide ¶ 47 and ¶ 48 in the review of this method). Second; from the loss to the functional ability of the two eyes, for with the loss of the functional ability of one eye, there is a loss of binocular vision and 1/6 of the binocular field of vision, which is indispensable for the functional ability of the two eyes. Muscular imbalance of the eye is a common concomitant of these losses so that the loss of the functions of one eye for economic purposes must inevitably be determined to be a loss of 1/6 to 1/5 of the functional ability of the whole body. By reducing these fractional losses to decimals, adding them together and dividing by 2, we obtain .18 as the standard of measurement which we have determined upon after considering this subject for many years.

tained, in the whole range of the science of numbers and the art of computation. It is a collateral branch of science which may be defined in terms of accumulated and verified knowledge formulated for the purpose of discovering and establishing the truth.

[6] In seeking the true value of anything, for instance like that of the earning ability of the body, it must be analyzed by the natural science method, by resolving it into its component parts, which are so interdependent that each is needed to ensure the status of the other, and then use these parts as factors in an equation, which is a statement in the formula of the thing that has been analyzed for the purpose of determining its true value according to the actual existing condition of these factors, on a basis of 1; that is to say, if each of the factors of the earning ability is found upon examination with instruments of precision, scientific standards of measurement and other data, to be normal and equal to 1., then the earning ability for the particular person who has been examined is normal and equal to 1. On the other hand, if one or more of the factors of the earning ability is found to be less than normal, or less than 1., by the same scientific procedure the earning ability will be less than normal, or less than 1., and the difference between what it is found to be and 1. represents the loss to the earning ability of the person upon which loss compensation must always be based. By virtue of the establishment of this principle it is self-evident that if after an injury or disease it is mathematically determined that a person has not sustained any economic loss to the earning ability in the vocation followed, then that person cannot be given a compensation upon economic grounds. Therefore, mathematics must be employed to determine the status of the earning ability of a person the same as mathematics must be employed to determine the actual value of anything else in the world on an economic basis.

[7] In concluding this introduction it is plainly evident that the status of the earning ability of a person, as obtained by the natural science method, is the key to the solution of every problem in which that person's economic value is concerned.

THE EARNING ABILITY OF THE BODY, ITS STATUS AND ITS LOSS

[8] As the true state of the earning ability of a person is the key to the solution of every problem in which that person's economic value is concerned, and as visual economics is a very important part of it, it is absolutely indispensable to determine this true state of the earning ability of a person by the only method known to physicists to determine the status of any physical force, or to economists to determine the value of any commodity in the whole range of the science of

numbers and the art of computation. The earning ability of the body must therefore be analyzed by the natural science method that its indispensable parts may be used as factors in its formula of multiplicand multiplied by a multiplier to obtain a product on the basis of 1. (¶ 6), which gives the status of the earning ability of the body from which its loss can be obtained in percentage upon which a compensation must always be based.

[9] By this analysis of E, the earning ability of the body, it is determined that the earning ability, is composed of three indispensable parts as follows:

First, F, the functional ability of the body. It is self-evident that the functions of the systems and organs of the body are absolutely indispensable to the earning ability of a person, for without them there would be no earning ability.

Second, T, the technical ability of a person. It is self-evident that a person must have training of the mind and body in order to be able to perform the duties of an occupation successfully, for without it that person would have no ability to earn anything and therefore would have no economic value.

Third, C, the competing ability of a person. It is also self-evident that a person must have the ability to secure work, or establish an occupation for himself and then perform the duties connected therewith successfully in order to have an earning ability, for without that ability that person would have no earning ability and hence no economic value.

[10] The three indispensable parts of the earning ability of the body may be used as factors in an equation as follows: (1) $F\ T\ C = E$, the statement of the earning ability of the body in the natural science formula for the purpose of determining its status according to the actual existing condition of its three indispensable factors.

[11] In order to discover and establish the true status of the first indispensable factor of E, the earning ability of the body, namely, F, the functional ability of the body, it must be analyzed according to the natural science method in the same manner as E, the earning ability, was analyzed. By this analysis, F, the functional ability of the body, is resolved

First, into its four units, in accordance with their development and associated functions, and

Second, each unit is resolved into its three indispensable parts, making twelve parts, or divisions of the body, within which the functions of every structure of a person may be included.

[12] The following is a chart showing the factors of F, the func-

tional ability of the body, obtained by an analysis according to the natural science method:

F =	a =	Osseous, articular and muscular systems, consisting of	h,	the bones.
			i,	the ligaments.
			k,	the muscles.
	b =	Circulatory and respiratory systems, consisting of	m,	the vascular system.
			n,	the blood.
			p,	the lungs and their accessory organs.
	d =	Digestive and genito-urinary systems, consisting of	q,	the alimentary canal and its accessory organs.
			r,	the kidneys with the genital organs.
			s,	the skin.
	g =	Cerebrospinal system, nerves and organs of special sense, consisting of	u,	the brain, its membranes and its nerves.
			v,	the spinal cord, its membranes and its nerves.
			w,	nerves and organs of special sense.

[13] Arranging the four units as factors of F, the functional ability of the body, we have the equation as follows: (2) a b d g = F, the statement of the functional ability of the body in its formula for the purpose of determining its true status from the status of its four units used as factors.

[14] Arranging the parts of each unit as factors of that unit in a similar manner we have the four equations as follows:

(3) h i k = a,
(4) m n p = b,
(5) q r s = d,
(6) u v w = g,

The statement of each unit of the body in its formula for the purpose of determining by examination with methods and instruments of precision, scientific standards of measurement and other data the true status of each of the four units of the body for the statement of F, the functional ability of the body, as per statement in formula (2), by which we obtain the complete amplified formula (7) (h i k) a (m n p) b (q r s) d (u v w) g = F.

[15] With the right conception of the solution of this problem everything proceeds in a logical manner when the natural science method is employed and every step can be checked up with actual existing conditions of the two indispensable factors of the earning ability of the person, so that there are no mysteries and it is as free from empirical methods as the determination of longevity upon which the life table is based, and upon which one of the largest businesses of the world has been successfully carried on for years.

[16] Although T, the technical ability, is an indispensable part of the earning ability of a person, nevertheless when the technical ability is impaired from injury or disease the impairment is caused by a loss of the functional ability of the brain, and hence this loss is partly accounted for in the loss to the functional ability of the brain, and the rest of the loss this causes to the earning ability is accounted

for in the damage to the competing ability of that person. Therefore, T, the technical ability, may be discarded in determining the loss to the earning ability of a person from injury or disease, and we have the formula reduced to the simplest terms of two factors, as follows: (8) F C = E, the statement of the earning ability of a person in the natural science formula for the purpose of determining its status from the loss upon which a compensation must always be based.

Anyone who is capable of understanding the solution of visual economics cannot help seeing that the formula in this form corresponds to the simplest terms of arithmetic, first taught us in childhood, namely, that F is the multiplicand, and C is the multiplier, and E is the product, the only way known to determine by computation the true value of anything in the world, in the whole range of the science of numbers and the art of computation.

[17] In formula (8) F C = E, in normal conditions, the coefficient of each of the factors, F and C, is 1., and therefore E = 1. If from injury or disease there is a loss to F, the functional ability, of 1., then its coefficient becomes O, and hence E = O, and therefore there has been a total loss or a loss of 100 per cent. If in a given case the loss to F be less than 1., namely, .36 for the complete loss of the sight of both eyes, then its coefficient becomes .64F, and "the primary coefficient of C, the competing ability," becomes .64C, and we have an equation as follows: .64F .64C = E, the statement of the earning ability in the formula for the loss of the sight of both eyes. Now, if the damage to C, the competing ability, is 1., its coefficient becomes O and the damage therefore is 100%, as in the case of the functional ability; but in the case of the loss of the sight of both eyes it is self-evident that the coefficient of C, the competing ability, does become O, because such a person does not, on the law of average, have any competing ability of economic value. Hence, this factor C becomes O, hence E = O, according to a mathematical law that when in any computation one of the factors becomes O, the product is O also. The actual total damage cannot be over 100%, and of course the actual damage to C, the competing ability of a person, cannot be over 100%. We, therefore, have a range for the damage to C, the competing ability of a person, between these two cardinal points of no damage, to 100% damage. For convenience we divide this range of 100% into three groups, and designate them slight, severe and nearly total, which three groups would include all the different degrees of damage to C, the competing ability, which could ever take place between the two cardinal points of no damage to C, to total damage to it, that could possibly occur from any loss to

F, the functional ability of the body from injury or disease. Thus the method of the determination of the damage to C, is all-embracing and flexible enough to meet every actual existing condition that can possibly occur from damages to the functions of the body from injury or disease in a manner equitable to all concerned.

[18] In our first study of arithmetic we were taught the axiom that increasing the multiplier increased the product and decreasing the multiplier decreased the product. In order to meet the condition in a given loss to the functional ability of the body which causes a greater damage to the competing ability than the loss to the functional ability, "the primary coefficient of C, the competing ability," the multiplier, which of course is a fraction, must be decreased in its value to decrease the product, the earning ability of the person, and thereby give a greater loss to it. To decrease the value of a fraction according to a mathematical law we multiply it by itself, for example: $.5 \times .5 = .25$. This process is called involution, and may be expressed thus: $.5^2 = .25$, the exponent of the fraction indicating the number of times it is to be used as a factor, or the power to which it is to be raised. On the other hand, to increase the value of a fraction uniformly and with mathematical precision, we must reverse the process of involution; that is, find a factor of it which multiplied by itself the required number of times will produce the fraction, for example, the factor of .25 which multiplied by itself is .5, because $.5 \times .5 = .25$. This may be expressed thus: $.25^{1/2} = .5$, it being an expression for the reverse process of involution by the reverse of the exponent 2, used in the involution example, thus: $.5^2 = .25$. This process consists in extracting the root of a fraction and is called evolution. Computations are made by it with "the primary coefficient of C, the competing ability" in Table 1. The process of involution and evolution is so simple that it should be readily understood by anyone capable of comprehending the solution of the compensation problem.

[19] From a loss to F, the functional ability of the body, from .01 to .80, thus giving it a coefficient of from .99 to .20, and hence "the primary coefficient of C, the competing ability" of the same value, we are able by involution and evolution to grade the status of the earning ability of the body through the damage to the competing ability between the two cardinal points of a slight percent. of damage to it to a nearly total percent. of damage to it; thus giving a range and gradation to the status of the earning ability of the body of sixteen different degrees from which the loss to the earning ability of the body can be obtained in percentage (as per Tables 3 and 4), upon which compensation must always be based.

[20] With reference to the computations in Tables 1 and 2, it is plainly evident that they represent the status of the earning ability of the body from two distinct sources, as follows:

First, from the loss to the functional ability of the body due to a loss of the function of some system, or organ, of the body, for instance like the loss of the function of one eye, the standard of measurement for which is .18 of F, the whole functional ability of the body, and determines the status of its coefficient as .82F, which always remains the same in every computation.

Second, from the damage to the competing ability of the person, namely, that of "the primary coefficient of C, the competing ability," which is .82C.

[21] The computations for the status of the earning ability for the loss of the functions of one eye range from a status of .8036 to .1125, entailing a loss from the 1° slight loss to it of 19.64%, to a 5° nearly total loss to it of 88.75%. In the 1° slight loss to it of 19.64%, 18% is of course due to the loss of the functions of one eye, and the remainder of 1.64% is for the damage to the competing ability. In the 5° nearly total loss to it of 88.75%, 18% is of course for the loss of the functions of one eye, and the remainder of 70.75% is for the damage to the competing ability of the person. Here we have a range between the two cardinal points of no percent. damage to the competing ability to one of 100% damage to it, which of course embraces all the damage than can possibly occur to it, for it is impssible to have more than 100% damage to anything. This damage to the competing ability, it will be seen begins with a damage of 1.64% and ends with a damage of 70.75%, which is divided into sixteen different degrees,—a range and gradation sufficient to meet every possible damage that might be required for any such loss to the functional ability of the body, no matter what function of a system or organ of the body might be involved, or what vocation the person might follow, unless perhaps in some rare instances the damage to the competing ability of the person (in the vocation he followed, or in any vocation he could follow successfully) might be total, when of course there would be a total loss to the earning ability of that person.

[22] It will thus be seen that Tables 1 and 2 provide the complete computations in tabular form for all the actual existing conditions of C, the competing ability of a person, after damage to the functions of the body from injury or disease, thus giving a status of the earning ability between the two cardinal points of 1° slight loss to it to the 5°

nearly total loss to it, for the loss to the functional ability, and for the damage to C, the competing ability.

[23] Tables 3 and 4 are obtained by subtracting the status of the earning ability in Tables 1 and 2, from 1., which gives the loss to the earning ability. It will be seen then that Tables 3 and 4 are complementary to Tables 1 and 2, and as they give the loss to the earning ability of the body for all the computations made, it is not necessary to go into the details of the computations which constitute Tables 1 and 2, but as soon as the loss to the functional ability is determined, in the form of a decimal fraction, to go direct to Tables 3 and 4, and looking down Col. 1, loss to F, until we come to the same decimal fraction, where we find on a line with it all computations giving the loss to the earning ability of the body from such a loss to F, the functional ability, together with the damage to C, the competing ability, as herein described.

[24] For an aid in the determination of the damage to the competing ability, and through it, its part of the loss to the earning ability of the body, the sixteen computations, obtained by the practise of decreasing "the primary coefficient of C, the competing ability" (the multiplier) by involution and increasing it by evolution between the two cardinal points of no per cent. of loss to it to total loss to it, have been divided into three groups and designated slight, of which there are five degrees; severe, of which there are six degrees; and nearly total, of which there are five degrees. These tables have been formed on the basis herein set forth for the purpose of shortening and simplifying the computations in the solution of these problems. They have been found of such inestimable service in this respect that many have informed the author that they considered the conception which led to their formation a great inspiration.

[25] It is self-evident that the values obtained by the natural science method in these tables can be employed in solving the compensation problem just as readily as those values obtained from any tables designed to shorten the process of computation.

EXAMPLES SHOWING THE NATURAL SCIENCE METHOD BY WHICH VISUAL ECONOMICS CAN BE SOLVED

[26] For the purpose of demonstrating that the damages to the functions of the eyes should be determined in exactly the same way as the damages to any commodity, the damages to several kinds of cloth from fire and water in one of the twelve divisions of a department store will be taken as examples. After measuring the unburned cloth and getting bids from several parties who are in the market to

buy damaged goods, an inventory of the damage to the several kinds of cloth and the value of the remainder of each kind was made and accepted both by the managers of the department store and the insurance company; namely, of 100 yards of each of the six different kinds of dress goods, 18 yards of each were so much burned that they were designated destroyed by fire. The best price for the remainder is given in a decimal which represents cents, and when multiplied by the number of yards of unburned cloth, which is the same in each case, we have the product in whole numbers and a decimal which represents dollars and cents. As the cost of each kind of cloth was $1.00 per yard, its value was $100, and when the product of each multiplication is subtracted from $100, and the remainder divided by 100, the loss is in percentage, and represents the loss to each piece of cloth and to the owner, as follows:

[27] Condensed Statement of the damage from fire in the dress goods division of a department store, by the bookkeeper.

Kind of Cloth	(1) Yds. left		(2) Price per yd.	(3) Value	(4) Loss	(5) Percent loss
Example 1—Cashmere.....	82	×	.98	=80.36	=19.64 =	19.64%
Example 2—Gingham.....	82	×	.82	=67.24	=32.76 =	32.76%
Example 3—Galatea......	82	×	.6724	=55.13	=44.87 =	44.87%
Example 4—Chambray	82	×	.5513	=45.20	=54.80 =	54.80%
Example 5—Muslin.......	82	×	.1372	=11.25	=88.75 =	88.75%
Example 6—Voile.........	82	×	.0	= 0.	=100. =	100%

[28] It will be noticed that the cashmere sold for 98 cents, which was as near its original price of $1.00 as could be expected and have any damage done to it; hence, this would certainly be designated a slight damage to the cloth, or in other words, a slight damage to its competing ability in the market. It will also be seen that the voile was so much damaged that nothing was offered for it; hence it was a total loss. We thus have a range between the two cardinal points of no damage and total damage, which is a 100% range. As the number of yards burned in each piece of cloth was determined by the standard of measurement of the yard stick, the remainder of each piece of cloth, or the functional ability of the cloth, becomes a fixed quantity, the price varying according to the quality, it being determined by the market price, the same as all commodities, and the same, we might say, as the price of labor, for the price of labor, whether a person be normal in all his functions, or subnormal in some of them in consequence of damage to the body from injury or disease, is determined

by its efficiency and the law of supply and demand. As each piece of cloth cost $1.00 per yard, the price at which the unburned damaged cloth could be sold for must range between 100 cents and no cents per yard. A reasonable and practical division of this range of the damage to the cloth is as follows: slight, to which the cashmere belongs, as it was damaged but 2 cents on a yard; Severe, to which the gingham, galatea, and chambray belong; Nearly total, to which the muslin belongs; and Total, to which the voile belongs.

[29] In one of the twelve divisions of the same department store, in which drugs, chemicals and explosives are kept for sale, an explosion occurred. An extract from the medical examiner's report is as follows:

	Loss to F	Damage to C
Example 1—J. C. Cashmere, bookkeeper		
R.E. V. N ; Fd. and Mf. N. L.E. V. 9/200; Scar of cornea, St.; Fd. and Mf. N.	.18;	St.1° = C^{1-10} = (.98)
Example 2—G. H. Gingham, floor-walker,		
R.E. V. N ; Fd. and Mf. N. L.E. V. 4/200; Scar of cornea, Se.; Mf. N.	.18;	Se.2° = C^{1} = (.82)
Example 3—J. G. Galatea, a salesman,		
R.E. V. N ; Fd. and Mf. N. L.E. V. 0/200; No Fd., Mf. N.;	.18;	Se.3° = C^{2} = (.6724)
Example 4—A. B. Chambray, clerk,		
R.E. V. N ; Fd. and Mf. N. L.E. Eye removed	.18;	Se.4° = C^{3} = (.5513)
Example 5—S. M. Muslin, a druggist,		
R.E. V. 0/200; No. Fd. Mf. good, L.E. V. 20/50 ; T. and Na.Fd.60°; Mf. good	.30;	Nt.5° = C^{10} = (.1372)
Example 6—J. V. Voile, Chemist,		
R.E. Eye removed L.E. V. 20/200; T. and Na.Fd.50° Mf. good	.36;	Tl. = C^{0} = (0)

[30] By taking the loss to F, and the damage to C, (or C with its exponent as a guide to the right computation), we go direct to Tables 3 and 4, and readily make the determination as follows:

Example 1—Percentage of loss to E., of Mr. J. C. Cashmere	19.64%
Example 2—Percentage of loss to E., of Mr. G. H. Gingham	32.76%
Example 3—Percentage of loss to E., of Mr. J. G. Galatea	44.87%
Example 4—Percentage of loss to E., of Mr. A. B. Chambray	54.80%
Example 5—Percentage of loss to E., of Mr. S. M. Muslin	88.75%
Example 6—Percentage of loss to E., of Mr. J. V. Voile	100 %

The determination of the loss to the earning ability of a person is made as quickly from the report of the medical examiner by the use of Tables 3 and 4, as it is possible to use any table designed to shorten the process of computation.

[31] In order to make the comparison between the damage to the six men, and to the six pieces of cloth as complete as possible, the computation for the determination of the loss to the earning ability of each of these men will be carried out in a manner similar to the computations for the determination of the loss to the earning ability of each of the pieces of cloth. It will be noticed that the exponent of C, the competing ability, indicates the damage to it, the same as the abbreviation of the words slight (St. 1° = $C^{1/10}$ = .98); severe (Se. 2° = C^1 = .82); (Se. 3° = C^2 = .6724), and (Se. 4° = C^3 = .5513); Nearly total (Nt. 5° = C^{10} = .1372) and Total (Tl. C^0 = 0).

Example:	(1) Loss to F = .18 Hence:		(2) Damage to C		(3) Product = E	(4) Loss	(5) Percent loss to E
1—Mr. Cashmere	.82F	×	$.82C^{1-10}$	= (St. 1°) = (.98)	= .8036	= .1964	= 19.64%
2—Mr. Gingham.	.82F	×	$.82C^1$	= (Se, 2°) = (.82)	= .6724	= .3276	= 32.76%
3—Mr. Galatea..	.82F	×	$.82C^2$	= (Se. 3°) = (.6724)	= .5513	= .4487	= 44.87%
4—Mr. Chambray	.82F	×	$.82C^3$	= (Se. 4°) = (.5513)	= .4520	= .5480	= 54.80%
5—Mr. Muslin...	.82F	×	$.82C^{10}$	= (Nt. 5°) = (.1372)	= .1125	= .8875	= 88.75%
6—Mr. Voile....	.82F	×	$.82C^0$	= (Tl.) = (Tl.)	= .00	= 100.	= 100 %

[32] In comparing the computations in ¶ 27 with those of ¶ 31, it will be noticed that the figures in col. 1 are identical, only those representing the remaining functional ability of the cloth are in whole numbers, while those representing the remaining functional ability of the body of the six men are in decimals. The price (the multiplier) the cloth sold for is in decimals, hence the product is in whole numbers and decimals, while the competing ability (the multiplier) of the men is in decimals; and therefore, the entire product in each case is a decimal, the figures being identical in each case; therefore, the figures in col. 4 are identical and correspond to the products as to values. Hence, the percentage of loss in each case in col. 5 is identically the same, thus proving mathematically that the process carried on in the determination of the damage to each piece of cloth (its functional ability) and in the determination of the damage to the functional ability of the body of each of the men is the same in each case. The damage to C, the competing ability of each of the persons, is represented by the abbreviation of the words slight, (St.); severe (Se.); nearly total (Nt.); and total (Tl.), with a figure and the sign of a degree, indicating the degree, and a decimal giving the actual

degree of damage, the same as ¶ 27 for the cloth. This gives the same range of damage between the two cardinal points of no damage to the competing ability and total damage to it, which is a range of 100%, the same as in the cloth.

[33] Among the thousands of damages to the functions of the body incident to the world war that came up for my consideration at the Medical Section of the Bureau of War Risk Insurance, we will select examples and make brief extracts from the report of the Medical Examiner, as follows:

		Loss to F	Damage in degrees to C	Damage indicated by exponent		Actual status of C		Loss to E in %
Case 1, formerly a clerk, age 30								
R.E. V. 20/50; scar of cornea,								
Fd. and Mf. N.,								
L.E. V. N.; Fd. and Mf. N.		.09	St. 5°	C^{1-3}	=	.968	=	11.92
Case 2, formerly a mechanic, age 28,								
R.E. V.20/50; scar of cornea,								
Fd. and Mf. N.	.09							
L.E. V.20/35+(0.6) scar of								
cornea, Fd. and Mf. N.	.03	.12	Se. 1°	C^{1-2}	=	.938	=	17.46
Case 3, formerly a bookkeeper, age 29,								
R.E. V. 0/200; Fd. and Mf. N.,								
No. ext. defect, cause central;								
L.E. V. N.; Fd. and Mf. N.		.18	St. 1°	C^{1-10}	=	.98	=	19.64
Case 4, formerly a salesman, age 32,								
R.E. V. 20/20; Fd. and Mf. N.;								
L.E. V. 20/20; Fd. lost to 20°								
concentrically;								
Mf. N., No. ext. defect		.09	St. 5°	C^{1-3}	=	.968	=	11.92
Case 5, formerly a chauffeur, age 29,								
R.E. V. 20/20; T.Fd. lost to 12°;								
Mf. N.								
L.E. V. 20/20; T.Fd. lost to 12°;								
Mf. N.		.18	Se. 2°	C^{1}	=	.82	=	32.76
Case 6, formerly a farmer, age 32,								
R.E. V. 20/30; Fd. N., complete paralysis of each external rectus,								
L.E. V. 20/30; Fd. N., operation enabled him to see straight ahead with one eye.		.20	Se. 2°	C^{1}	=	.80	=	36.00
Case 7, formerly a machinist, age 31,								
R.E. V. 20/50; Fd. St. loss	.09							
Mf. N.	.03							
L.E. V. 20/30; Fd. St. loss	.03							
Mf. N.	.03	.18	Se. 1°	C^{1-2}	=	.906	=	25.71

		Loss to F	Damage in degrees to C	Damage indicated by exponent	Actual status of C	Loss to E in %
Case 8, formerly a farmer, age 28, R.E. V. 20/20; Fd. and Mf. N. L.E. V. 8/200; Detachment of retina; Mf. N.		.18	Sc. 2°	C^1 =	.82 =	32.76
Case 9, formerly a farmer, age 31, R.E. V. 0/200; No Fd., Mf. N.,	.18					
L.E. V. 20/60; T. and Na. Fd. lost to 60°; Mf. N.	.15	.33	Sc. 2°	C^1 =	.67 =	55.11
Case 10, formerly a druggist, age 29, R.E. V. 3/200; Scar of cornea Fd. and Mf. N.	.18					
L.E. V. 20/20; Fd. and Mf. N., Tl. loss of H. in R. ear	.12	.30	Sc. 2°	C^1 =	.70 =	51.
Case 11, formerly a chemist, age 32, R.E. V. 20/20; Fd. and Mf. N.	.18					
L.E. V. None. Eye removed, the same injury damaged the nose to such an extent that there was an entire loss of the sense of smell, the nasal passages being so nearly occluded that he had to breathe through his mouth and his voice had the sound as though "talking through his nose," which, of course, was caused by nasal stenosis.	.12	.30	Sc. 3°	C^2	= .49 =	65.70
Case 12, formerly an attorney, age 32, R.E. V. 20/20; Fd. and Mf. N. L.E. V. 8/200; Scar of cornea; Fd. and Mf. N. Left hand amputated at wrist, wearing an artificial hand, Loss to L.E. .18 Loss for L. hand .20 Making use of formula (2); hence we have: .80a b d .82g = F. Hence, F = .656. Hence the loss to F = .344, called .34, which is .04 less than that obtained by addition,—(.18 + .20 = .38)		.34	Sc. 3°	C^2	= .4356 =	71.26
Case 13, formerly a skilled machinist, age 33, R.E. V. 20/20; Fd. and Mf. N.						

	Loss to F	Damage in degrees to C	Damage indicated by exponent	Actual status of C	Loss to E in %
L.E. V. 20/25; Fd. and Mf. N. The periphery of each cornea presents scar tissue making a conspicuous cosmetic defect, damaging his competing ability to severe degree.	none	Se.			

[34] In case 13, F, the functional ability of the body, has not been damaged, but the scar tissue in the periphery of each cornea makes a conspicuous cosmetic defect, damaging C, the competing ability to a severe degree, not only because some employers would suspect defective vision but they would object to having a person in their employ who showed such a conspicuous cosmetic defect. Can we ascertain the loss to the earning ability of a person through the damage to C, the competing ability of that person alone, on a mathematical basis? Certainly not, for but one factor is damaged and we cannot solve a problem with one factor no matter what we do with it or to it. Therefore, the loss to the earning ability of such a person must be estimated, and the compensation for it governed accordingly.

EMPIRICAL METHODS USED IN THE COMPENSATION PROBLEM

[35] Magnus' contributions to the scientific solution of the compensation problem in visual economics, as translated by Würdemann, enunciated principles far in advance of anything that had ever been published, in that he had the true conception of the complete earning ability of the body, analyzed it according to the natural science method, determined its indispensable factors and stated them in its formula in terms which must ever remain classical. He, however, did not have that competing ability necessary to make this analysis effective and therefore, never used it. Magnus adopted a method in which he built up "a formula for the act of seeing in relation to earning" on the assumption that the functional ability of the eyes is the whole functional ability of the body, instead of just what it is really, namely, an important part of it. Magnus resolved the physiologic act of vision into its factors for the earning ability of the eyes, in which, in a case like that of the clerk, in ¶ 33 (1), the functions of the less injured, or normal eye, constitute F, the functional ability (the multiplicand) in the formula, and the status of the injured eye and less injured or normal eye in arithmetical pro-

portion constitute K, the competing ability, (the multiplier); thus stating the earning ability of the clerk as follows:

$$E = C\ (\text{max})\ \sqrt{P}\ \sqrt[4]{M}\ (F)\ \sqrt[x]{\frac{0.4+1}{2}\ \sqrt{P}\ \sqrt[4]{M}\ (K)}$$

The result is that when a solution is made of this formula the values in it, constituting F, the functional ability (the multiplicand) between E, and the radical sign, with x for its index, become 1; just what they were when they were put into the formula under a radical sign;—they had neither lost nor gained by this process, for any root of 1, is always 1. The functions of the left eye of the clerk were determined by the medical examiner to be normal, and therefore, they must equal to 1. in any place they might be put, and as such they may be discarded, because if 1. is used for the multiplicand, the product would be the multiplier, that is, its value would not be changed. This leaves the formula without a multiplicand and with only one factor, namely, K, the competing ability (the multiplier). It is self-evident that to attempt the solution of a problem with one factor is to attempt to violate an indisputable law of mathematics, namely, that there must always be at least two factors to solve any problem. If, as in this formula, after discarding the multiplicand you have only the multiplier left, you cannot multiply because you have nothing with which you can multiply. Magnus failed to recognize this fact, but it is a mystery how it failed to escape the attention of the expert mathematician, whom, it is said in the preface, he called to his aid. As to K, the competing ability, (the multiplier) that remains of the formula the $\sqrt{P}$, the field of vision, and $\sqrt[4]{M}$, the muscular functions, of course become 1, the same as they did in the multiplicand, and the formula is reduced to: $E = \sqrt[x]{\frac{0.4+1.}{2}}$ Hence, $E = \sqrt[x]{0.7}$, which in reality is that $E = 0.7$; the 0.7 representing the status of the clerk's vision, which by Magnus' method is E, the status of the earning ability. The medical examiner, however, determined the vision of the left eye of the clerk was normal, hence this method of arithmetical proportion (which is used in so many empirical methods) determines a wrong value for vision. As a status of $E = 0.7$, would give a loss to it of .3 or 30%, this loss Magnus deemed too great for the loss of vision in one eye to 20/50; so he employed evolution to increase 0.7, the status of E, at this stage of the solution, and selected 10 to take the place of x. Hence, the equation without the factor of its multiplicand becomes $E = \sqrt[10]{0.7}$. Therefore, $E = .965$, and the loss is .035, or 3.5%, as against that determined in ¶ 33 of 11.92%.

[36] Had not Magnus made the fatal error "in building up a formula for the act of seeing in relation to earning" on the assumption that the functions of the eyes are the whole functional ability of the body (as is also done in all empirical methods), but had used them for just what they are really, namely, an important part of the whole functional ability of the body, and therefore, an important part of the "full earning ability" as would be implied from his analysis of it, the great fundamental principles which he contributed towards the solution of the compensation problem in visual economics would have been made available many years before they were so made in physical economics.

[37] Magnus' conception of the earning ability is as follows (Pages 26, 27 and 28, V. E.):

"If we would conceive of an injury to the earning ability as a quantity which can be given a mathematical value, we would have to start from an estimation of the complete earning ability, which in a healthy normal individual is a composite quantity resulting from three factors:

"(1) The unimpaired functional power of the bodily organs.

"(2) The technical knowledge which is necessary for the carrying on of the vocation.

"(3) The ability of the individual to compete in the labor market.

"These elements cannot be regarded as equal in value. Doubtless the functional conditions of the bodily organs is of the first importance for successful work. The preparatory education or knowledge is of nearly equal value. Much less importance should be given to the third element, the ability to compete in the labor market. This is dependent upon the value of the two others, because the ability of an artisan to battle against competition depends largely upon the condition of his health and his technical knowledge—our two first elements. We have divided the conception of the earning ability into its three fundamental elements solely because such an analysis makes it possible to put the normal earning ability into a mathematical formula. Thus we designate the earning ability itself E; the first of our elements, the functional ability, F; the second, the necessary knowledge, V; and the third, the ability to compete, K. In this formula we put the two quantities, F and V, in their full value and accept K as a root value. There would be nothing changed in the total value of the formula itself because as the root of 1 is always 1, and we regard F, V and K as 1, it is immaterial for the formula itself if we take one of the three quantities as a root or not, but this proportion immediately changes when the part introduced as a root grows smaller than 1, as happens in each ocular injury, because the root of each genuine fraction is always greater than the fraction itself.

"When we express the earning ability through the three factors, F, V and K, we present E, not as a sum, but as the product of these quantities, as multiplied thusly: $E = F\ V\ \sqrt[x]{K}$, in which the exponent x changes with the degree of the functional damage. E must always be regarded as a product and not as a sum, to meet all possibilities occurring in practice. If we add F, V and K, the formula would give wrong practical results, as we see in the following example: Supposing both eyes were lost in an accident, the quantity F of our formula would be O. If we had connected F, V and K with the + and added, even if K would have become O, $V + \sqrt{K}$, which is the remainder of the earning ability, would have been left. This would be entirely wrong, because a laborer who has lost his functional ability, especially the sense of sight, should be regarded in an optical way as entirely unable to earn. Taking the same example and using our formula with $F = O$, E immediately becomes O, because each product is always O if one of the factors is O. If we would leave V out of our formula, E of course = O, and actual practice confirms this, because even the most simple hand work requires a certain amount of preparatory education. Finally, if we drop the third factor, the 10th root of K, the normal earning ability according to our formula becomes O, which is likewise shown by practical experience, because, even though an individual is in good health and by reason of preparatory education has the skill to work, if his work is not needed, his economic value is nil. He may possess the power of working, as the factors F and V are present, but he only has earning ability when he can dispose of the work in the economic market.

"The calculation of injury to the earning ability proposed by us starts from the formula for the full earning ability:

$$E = F\ V\ \sqrt[x]{K}."$$

[38] Magnus discards V, the technical ability, for the same reasons that are given in ¶ 16, and the formula thus simplified is as follows: $E = F\ \sqrt[x]{K}$, which corresponds to formula (8) $F\ C = E$ (¶ 16), and is the formula used in ¶ 35. The symbols F and K are

exhibited in parenthesis to make it more apparent, that this is so, as follows:

$$E = C\ (\text{max})\ \sqrt{P}\ \sqrt[4]{M}\ (F)\ \sqrt[x]{\frac{0.4+1}{2}\ \sqrt{P}\ \sqrt[4]{M}\ (K)}.$$

[39] Although Magnus' formula is built up on the assumption that the earning ability of the eyes is synonymous with the earning ability of the body, this, it will be seen, is not true according to his own true analysis of the "complete earning ability of the body"; nevertheless, many of his reasonings and deductions in regard to the indispensable factors of the earning ability coincide with this true conception and therefore are a great contribution to the solution of the problem of visual economics.

[40] The meaning and estimation of the ability to compete is one of these contributions, as follows: (Page 46, V.E.)

"When an individual receives an accidental injury, especially that of vision, the damage to him is a double one. First, there is the impairment of his working ability from the results of the accident in that he cannot perform as good or as much work as formerly, and second his chances for obtaining work quickly and easily are less. This second factor is not so unessential as one might suppose. Practical experience shows that the one-eyed person not only has more difficulty in finding employment, but that in some factories his visual disorder makes it difficult for him to retain his employment. Workmen with sound eyes are preferred by most employers of labor and from their standpoint, certainly not without reason. The injured person, therefore, has a right to claim not alone a compensation for the impairment of his capacity for work but also the difficulty which he encounters in making the most of his capacity. Therefore, in estimating the impairment of the earning ability, we have always and under all circumstances to consider the diminution of the ability to compete.

"The ability to compete is a conception resulting from a combination of heterogenic elements of which a part lies in the individual himself and is affected by the condition of his health, his knowledge, etc., while another portion is beyond his control. It is this latter element the world values in judging the ability of the individual. The ability to compete in the labor market, the possibility of finding employment, is fixed, therefore, by the physical and mental ability of the individual as well as by the way others judge of it. If we apply this reasoning to the organ of vision, the ability to compete of each individual will depend firstly upon the ability of the visual organ and secondly upon the way the others are judging its condition; an example should render this clear. Supposing someone has suffered an injury to one eye and seeks employment, his chances of obtaining the desired work will depend first, upon his visual powers and second, upon the way the employer judges them. The employer will be willing to give or refuse work to this particular individual according to how he regards the injury of the eye as detrimental for the performance of his particular work."

[41] Although these reasonings on the ability to compete are true according to the true conception of the earning ability of the body as given in ¶ 37; nevertheless, when Magnus undertakes to adjust the competing ability in his formula for the ocular earning ability he adopts a purely empirical method, for he says: (Pages 47 and 48, V.E.)

"If we would indicate that the employer regards a certain ocular impairment as an important diminishment of the working capacity we would take a smaller exponent, but if we intend to show that an ocular impairment is of less importance to the employer, we would take a greater one. We, therefore, choose for all slight and moderate visual impairments a different root exponent than for the serious ones; therefore, for the slight impairments we give the ability to compete the root exponent 10, but if the impairment of central vision is serious, i. e., in the case of professions with higher visual demands if it falls below 0.15 and in those with less demands below 0.05, and instead of the root exponent 10 we take the exponent 5 for these professions with greater visual demands and the exponent 7 for those with less. The same is to be done in the case of the complete loss of one eye or in the case of the loss of the eyeball. If we think that the aesthetic differences between simple blindness of the scientific standard without injury to the looks of the eye and the loss of the eyeball, or, for instance, the formation of a bad looking eye, as leucoma or staphyloma are greater, we may give expression to our opinion by choosing a great root exponent for the ability to compete in the case of simple blindness without deformity. By leaving the selection of the root exponent to the judgment of the calculator, sufficient room is given for the individual conception of each case; thus our formula adapts itself to the peculiarities of the individual case and to the judgment of the physician, avoiding thereby a rigid form and doing justice to both parties. Therefore, in forming a special estimation of the ability to compete we first fix the amount of the injury to the act of vision in each case, and upon this depends that part of the ability to compete which the individual furnishes himself. As regards the second part, in certain cases it will be found that while there is no or but little actual injury to the visual sense itself, yet certain injuries to the eye disturb the relations of the individual to the employer.'' (P. 47 and 48, V.E.)

[42] To show to what extent this empirical method leads Magnus, the following is quoted: (P. 48, V.E.)

''Such a case as the following is often experienced in practice: A man has his cornea burned by lime which leads to the formation of leucoma and diminishes the visual acuity of that eye to 0.25 of the normal, the other eye remaining well. Thus, although such an individual is not optically impaired for his work because the normal eye allows the undisturbed following of his trade, the chances of his finding work have became less. A great many employers would hesitate to take into their service a man with a bad looking eye, who shows so plainly the effects of the injury or who, they know, can see normally only with one eye; in spite of the fact that in such a case an actual impairment has not taken place the ability to compete is certainly diminished. We are consequently in the peculiar position of estimating an ocular impairment of the ability to compete when there is no real defect of working vision. Thus we think we can meet these difficult conditions in the best manner if we express the diminution of the ability to compete in all cases by the arithmetical proportion of the visual acuity of both eyes.''

[43] The reasonings set forth in quotations from P. 26, 27 and 28 have not been followed in quotations from P. 46, 47 and 48; for when it is stated that the sight of one eye has been reduced to 0.25 of normal, from a scar of the cornea, due to a burn from lime, certainly the functions of one eye have been damaged to that extent.

If, with the other eye remaining normal, the loss in the functions of one eye does not damage the functional ability of that person in the vocation followed, then we contend that such a person has not sustained a loss that can be given a mathematical expression. If, notwithstanding this, there was a damage to the competing ability of that person, as alleged, then such a damage should be estimated ¶ 34. Any attempt to solve the problem in this way is contrary to the true conception of the earning ability of the body, and therefore, to the laws of mathematics. It comes about on the assumption of Magnus that the functional ability of the eyes is the whole functional ability of the body, and the necessity by virtue of this false assumption of obtaining the coefficient of the functional ability of the eyes by one method and the coefficient of the competing ability of the eyes by another method, thereby leading to the absurd position that there has been no damage to the functional ability of the eyes, for Magnus says: "We are consequently in the peculiar position of estimating an ocular impairment of the ability to compete when there is no defect of working vision." Magnus set his extraordinary reasoning powers to work to extricate himself from this position, and doing so, his logic led him into a graver one of solving this problem with but one factor,—that of the damaged factor of the competing ability alone, thereby causing him to transgress an indisputable law of mathematics, namely, that it is always necessary to have at least two factors to solve any problem.

[44] A reference to the analysis of the body as represented in the chart ¶ 12, shows that the coefficient of F, the functional ability of the body, depends upon the condition of its twelve factors. The coefficient of C, the competing ability, depends, physically, upon the functions of the same identical structures, for without them there would be no competing ability ¶ 9; hence, its primary coefficient must be the same ¶ 17.

[45] If after an injury we do not find any loss to the functions of the body according to scientific and economic standards of measurement, then there cannot be a loss to the competing ability that can be given a mathematical expression ¶ 34 for we would have but one factor. If we attempt to solve a problem with one factor alone, whatever we do with it or to it, we then and there abandon a mathematical basis for an empirical basis for solving it.

[46] On page 54 (V.E.) Magnus gives an example 2, in which the vision of one eye is reduced to 0.4 and in the other to 0.3 of normal by an injury, which when stated in the formula, according to the economic value of the vision, is as follows: (F and K are inserted in the formula to indicate what constitutes the coefficient of each).

(1) $E = C\ .41\ (\text{max})\ \sqrt{P}\ \sqrt[4]{M\ (F)}\ \sqrt[x]{\frac{C\ .41+C.25}{2}\sqrt{P}\ \sqrt[4]{M}}$ (K), Hence

(2) $E = C\ .41 \text{ x } 1 \text{ x } 1\ (F)\ \sqrt[x]{33} \text{ x } 1 \text{ x } 1\ (K)$, Hence

(3) $E = .41F \text{ x } \sqrt[5]{.33K}$, Hence

(4) $E = .41F \text{ x } .806K$, Hence $E = .3304$, and the loss is .6696, or 66.96%.

Just notice that the loss to F, the functional ability, is .59 (obtained by subtracting .41 from 1.) for the loss of vision in one eye to 0.4. Just notice, too, that by arithmetical proportion the damage to K, the competing ability, is .67 (obtained by subtracting .33 from

1.), it being .08 greater, and obtained in an entirely different way from that of F, the functional ability.

[47] Let us show the absurdity of solving this example (2) by this method, by Magnus himself in establishing a standard for the economic loss to a person for the loss of the entire sight of one eye, as follows: (P. 88 V.E., F and K being inserted in the formula to indicate what constitutes the coefficient of each).

(1) $E = 1C \sqrt{\tfrac{5}{6}P}\ \sqrt[4]{\tfrac{2}{3}M}\ (F)\ \sqrt[x]{\frac{1C + 0}{2} \sqrt{\tfrac{5}{6}P}\ \sqrt[4]{\tfrac{2}{3}M}\ (K)}$,

Hence

(2) $E = 1C \sqrt{83\tfrac{1}{3}P}\ \sqrt[4]{66\tfrac{2}{3}M}\ (F)\ \sqrt[x]{\frac{1C+0}{2} \sqrt{83\tfrac{1}{3}P}\ \sqrt[4]{66\tfrac{2}{3}M}\ (K)}$,

Hence

(3) $E = .913 \times .904\ (F) \times \sqrt[5]{.4127}\ (K)$, Hence

(4) $E = .825F \times .838K$, Hence $E = .6914$, and the loss is .3086 or 30.86% for the loss of the entire sight of one eye.

From this computation Magnus' conclusions are as follows: "Approximately we may say that a one-eyed person has lost 30% of his earning ability for the first year after the accident, and 20% afterwards for higher class of trades, and for the lower class the proportion would be 27% for the first year, and 18% thereafter."

[48] Just notice that the loss to (4) in F is .175 (obtained by subtracting .825 from 1.) for the loss of the entire sight of one eye, while in the previous ¶ 46, the loss in (4) to F is .59, for the loss of the sight of one eye to 0.4. Could there be anything more absurd than in using a method which would give the loss to F, the functional ability, of .59 for the loss of the sight in one eye to 0.4, and in another case give the loss to F, the functional ability, of .175 for the loss of the entire sight of one eye? It simply comes about from "building up a formula for the act of seeing in relation to earning" on the assumption that the functional ability of the eyes is synonymous with the functional ability of the body, and by virtue of this assumption of employing the remaining functional ability of the eyes as the remaining functional ability of the body and obtaining the damaged status of the competing ability by another entirely different method, and then putting the different values of the functional ability and of the competing ability under a radical sign with different indices to increase these values according to the conception of the originator of this method, which of course is done purely on an

empirical basis, and therefore makes Magnus' method, which he employs in *Visual Economics*, an empirical method.

[49] The Bureau of Pensions of the United States gives for the

loss of the sight of one eye	$ 12.00	per month
on a basis of total disability of	100.00	per month
but previous to 1905, it was on a basis of	72.00	per month
for total disability, making it really a rate of	16.66+%	
compensation instead of as it still remains a rate of	12%	
for the loss of both eyes is now	100.00	per month
for the loss of an eye by its removal	17.00	per month
was given when for the loss of both eyes	72.00	per month
was given.		
If $17.00 be increased in the same ratio as the loss for both eyes, namely, from $72.00 to $100.00 per month it should be now	$ 23.60	per month
giving a loss on total disability of which it is an integral part of		23.60%

[50] No pension is given for a partial loss of sight, or for the partial or complete loss of the field of vision or the muscular functions of the eyes, notwithstanding a pension is given for the partial or complete deafness of one or both ears under the designation of slight, severe, nearly total and total deafness.

[51] The instructions to examining surgeons say that "the surgeon should differentiate between the loss of sight of an eye and the actual loss of an eyeball." In "the loss of sight of an eye" and in "the actual loss of an eyeball," the loss to the functional ability of the eyes, and through them, to the functional ability of the body, is the same. The only way then that it can be explained intelligently, and therefore correctly, why a pension of $12 per month is given for "the loss of the sight of an eye," and $17 per month for "the actual loss of an eyeball," is that the latter causes more damage to the competing ability of a person than the former, because employers can detect "the actual loss of an eyeball," whereas they would not be so likely to detect "the loss of sight of an eye," especially when the eye presented a good appearance. Therefore, the difference between the pensions given is readily explained in the damage "the actual loss of an eyeball" causes to the competing ability of a person, and shows conclusively that the compensation problem can only be solved correctly by determining the loss to the earning ability of the body through its two indispensable factors, namely, the functional

ability of the body, and the competing ability of the person, as has been conclusively proven in the preceding parts hereof.

[52] In a recent paper by Col. C. W. Belton, Medical Advisor of the Board of Pension Commissioners for Canada, after considering all the methods available, he says:

"As far as could be learned there was no basic principle from which might be deduced, in manner more or less logical, an award for any given damage. Yet it was fairly apparent that the effect of the damage on earning power was in some way concerned with the assessment."

In reference to his own Government he says:

"Although the present Regulations make no reference to earning power there is no reason to believe that this has been set aside. In fact certain clauses may be taken to confirm it. These clauses are important in other respects as well and should be carefully considered."

[53] The California "Schedule for Rating Permanent Disabilities," is an empirical method, pure but not simple. It is a written statement or an inventory for rating permanent disabilities, and therefore makes no pretensions to employ the natural science method to determine the loss to the earning ability of a person from damages to the functions of the body from injury or disease, upon which loss a compensation must always be based if it is to be determined by means of mathematics in the same manner as the value of any physical force, or any commodity, is ascertained in the whole wide range of the science of numbers and the art of computation.

[54] The California Schedule is made up of thirty tables, four of which must be employed to rate any case, namely, of so-called entries of 69:3 or under. For entries of 70:0 and over, the Pension Table must also be used. They are as follows:

Table I, gives (1) the disability number, (2) designates the disability, and (3) the line number.

Table II, First division gives (1) the occupation, (2) the industry and (3) the form number.

Table II, Second division, with the disability number and the form number it is readily determined which one of

Table III, composed of "Rating Tables A to Q is to be employed. With the line number and the age of the injured, a rating is obtained which is called "the entry." This is composed of a number, two dots and another number or 0.

[55] For "the entry" of 69:3, or under, the number to the left of the dots is multiplied by 4 and the number to the right of the dots is added. The result thus obtained is the number of weeks the compensation, which is 65% of the weekly wages, is to be paid to the injured.

[56] "For entries of 70:0 and over," the compensation in all cases includes two items, a fixed item and a variable one.

(a) Fixed item. The fixed item is the duration for 240 weeks following the fifteenth day after injury of payment of 65% of wages. These payments are made on behalf of the injured person's family.

(b) Variable item. The variable item is a life pension of a certain percentage of the injured person's former wage. Such pension begins at the end of 240 weeks and continues throughout the remainder of the injured person's life. The pension is paid for the support of the injured man himself. In order to determine the percentage of wages to be paid as a pension under the variable item the following table is given for all entries from 70:0 to 100:0, namely the

Pension Table, which for "the entry" of 70:0 gives 10% of the wages and for "the entry" of 100:0 gives 40% of the wages.

[57] Under the heading "How to Use the Tables for Rating Permanent Disabilities" the injunction is: "observe the following rules:

"I. As soon as possible determine accurately the following items:

"(1) The nature of the physical injury or disfigurement.

"(2) The occupation of the injured person.

"(3) The age of the injured person.

"(4) The average weekly wages of the injured person."

[58] The first item (1) reveals the conception of the author of this schedule for it has reference to the twenty-one groups that start with the skull and end with the toes, which are numbered in Roman numerals; while under each group the various degrees of disability are designated by Arabic numerals, and the two together constitute the "disability number." The conception thus revealed is that of an anatomical and pathological one for ascertaining a disability upon which to base a compensation, for it has no reference to the functions of the different systems and organs of the body upon which the status of the earning ability depends, and upon the loss of which compensations must always be based if they are to be determined by the natural science method,—the only method known to mathematicians by which the status of any physical force or any commodity can be determined.

[59] Under group "II, the Eye," thirteen examples are given. It is stated in the notes, however, that the disabilities given are not intended to be complete. When an injury consists of a combination of

losses, or a disability not enumerated, the case must be referred to the commission for rating.

[60] "Remediable injuries will not be considered permanent until all adequate and reasonable operations and treatment known to medical science have been used to correct the results, (of the injury or disease, it is presumed is meant) "The law allows unlimited medical cost to meet this case," and it is added, "it is better to correct the trouble than to continue payments for permanent disability due to lack of attempts at correction." It is noteworthy that by this schedule 65% of the weekly wages is taken in every case, and the compensation cannot exceed $20.83, nor be less than $4.17, per week for any person, no matter how much that person may earn.

[61] We will now consider the thirteen examples for the purpose of showing how the values are arrived at from the schedule and to more fully illustrate the conception which led to the production of this extraordinary "Schedule for Rating Permanent Disabilities."

[62] Table I. Nature of Disability

II. The Eye

Disability Number		Line
II—1.	Complete loss of both eyes	64"
II—2.	Complete loss of the sight of both eyes	64"

It is reasonable to assume that in example 1, both eyes have been removed, and in example 2, there is no perception of light from either eye. A correct statement from the records of a proper examination would eliminate any doubt about what was meant. On the assumption that in each case the injured person is 31 years of age, and was earning $30 a week, the examples are worked out as follows:

By the California Schedule

Table II. Occupation Form No.
1st Div. Bookkeeper 25
Table II. Form No. 25 and Disability No. II—1 and 2,
2nd Div. give Table A.
Table A, with line No. 64 and age 31, gives entry No. 100:0. The fixed item (a) is 65% of $30 = $19.50 for 240 weeks, or $4,680.

The variable item (b) is found by considering the Pension Table, and for an entry of 100:0, is found to be 40% of the wages. Therefore, 40% of $30, or $12, is to be paid as a pension to each of these blind persons, for the rest of their lives.

By the Natural Science Method

An extract from the Medical Examiner's report reads as follows:

Example 1
R. E. Removed.
L. E. Removed.
Example 2.
R. E. V. 0/200; No. Fd; Mf. not stated.
L. E. V. 0/200; No. Fd; Mf. not stated.
"Loss to F = .36
Damage to C = Total"

Hence, by Tables 3 and 4, the loss to E, the earning ability of each bookkeeper is 100%. Therefore, each blind bookkeeper should be paid $30 a week, or as much of it as is provided in the law of the state for such a total disability.

[63] Table I.

Disability Number — Line

"II—3. Complete loss of one eye..26"
(Occupation, Bookkeeper; Age 31; Wages $30 a week.)

By the California Schedule

Table II. Occupation Form No.
1st. Div. Bookkeeper 25
Table II. Form No. 25 and Disability No. II—3,
2nd. Div. give Table F.
Table F, with line No. 26 and age 31, gives entry No. 35:0 = 140 weeks. Therefore, 65% of $30, or $19.50, should be paid the bookkeeper for 140 weeks, making a total amount of $2,730 for the complete loss of one eye.

By the Natural Science Method

An extract from the Medical Examiner's report reads as follows:
R. E. Normal
L. E. Removed
"Loss to F = .18
Damage to C = Severe 4°."

Hence, by Tables 3 and 4, the loss to E, the earning ability of the bookkeeper, is 54.8% of $30, or $16.44, which is to be paid to him the number of weeks provided in the law of the State. To pay the same amount given by the California Schedule, namely, $2,730, it would have to be paid for 166.05 weeks.

[64] Table I.

Disability Number — Line

"II—4. Complete loss of the sight of one eye[1]..............................21"
(Occupation, Bookkeeper; Age 31; Wages $30 a week.)

By the California Schedule

Table II. Occupation Form No
Ist Div. Bookkeeper 25
Table II. Form No. 25 and Disability No. II—4,
2nd Div. give Table F.
Table F, with line 21 and age 31, gives entry No. 30:0 = 120 weeks. Therefore, 65% of $30, or $19.50, should be paid the bookkeeper for 120 weeks, making a total amount of $2,340.

By the Natural Science Method

(¶42-3)

An extract from the Medical Examiner's report reads as follows:
R. E. Normal
L. E. V. 0-200; No. Fd.; Mf. N.
"Loss to F = .18
Damage to C = Severe 3°."

Hence, by Tables 3 and 4, the loss to E, the earning ability of the bookkeeper, is 44.87% of $30, or $13.46. To pay the same amount given by the California schedule it would have to be paid for 173.84 weeks.

[65] The nine remaining examples are as follows:

Line

II— 5. Complete loss of the sight of one eye, plus such impairment of the sight of the other as prevents reading or writing, but not the ability to find one's way.
Slight..58
Moderate..60
Severe..62

II— 6. Loss of the sight of one eye, leaving no scar or blemish such as would afford an observer evidence of such loss.................................16

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[1] Without the records of an exact test of the vision, the statement "complete loss of the sight of one eye" could be taken as economic blindness instead of what is probably meant scientific blindness, that is, absolute blindness.

		Line
II— 7.	Permanent impairment of the vision of both eyes, to the extent of rendering them useless for purposes of higher visual requirements, but not for finding one's way	
	Slight	57
	Moderate	59
	Severe	61
II— 8.	Such a permanent impairment of the vision of one eye as renders it useless for purposes of high visual requirement, but not affecting one's ability to find one's way, the other eye being uninjured	6
II— 9.	Hemorrhage of the eye, causing defective vision at times only	6
II—10.	Paralysis of the muscles of both eyes by reason of injury to the sockets causing double vision	41
II—11.	Paralysis of the muscles of one eye by reason of injury to the socket of that eye, causing immobility and double vision	21
II—12.	Injury to the eye-socket, causing immobility of the eyeball with attending impairment of range of vision only	16
II—13.	Laceration of lachrymal duct causing chronic overflow of tears	6

[66] It is impossible for anyone to determine intelligently the loss to the functional ability of the eyes, and hence the loss to the functional ability of the body, and thereby the loss to the earning ability of the body, through the damage to the competing ability of a person without a carefully made and recorded examination of the three indispensable functions of the eyes, namely, (1) the central vision; (2) the field of vision, and (3) the muscular functions.

[67] The five examples from 5 to 9, the statement as to the loss to the functional ability of the eye, or eyes, has reference to (1) the central vision, alone, and the statement in regard to this condition is not according to any scientific or economic standard of measurement, for as it is stated there is doubt about just what degree of loss of sight is meant.

[68] In examples 10, 11 and 12, the statement about them has reference to the (3) muscular functions of the eyes. If an injury, or disease, causes double vision, so annoying that the eye has to be excluded, the loss to the functional ability of the eyes is the same as the loss of the functions of one eye; but the determination of the damage to the competing ability and through it the loss to the earning ability, requires an exact knowledge of (1) the central vision and (2) the field vision in such cases, and nothing is said about either of them in these three cases. In example 13, "laceration of the lachrymal duct causing chronic overflow of tears," nothing is said about the three indispensable functions of vision. If it is assumed that each of these functions are normal, then there would be no loss to the functional ability of the eye, as but one factor of the earning ability would be damaged, namely, the competing ability of the person. As the law allows unlimited cost to restore the functions of any structure that can be restored by treatment, there is no reason why "chronic

overflow of tears" should not be corrected by well-known surgical procedures. Excluding the first four examples, the description of the disability is so meagre in the other nine that it may well be left to the reader to determine for himself why this is so when due regard is given to what is said in the notes under Table I, namely, that "when the injury consists of a combination of losses, or a disability not enumerated, the case must be referred to the commission for rating."

[69] In the description of the nature of the disability in examples 5 and 7, each end with the words "but not the ability to find one's way," which would indicate that the disability in each case was about the same, yet three different lines of numbers are given for each of the disabilities, which are designated as "slight," "moderate" and "severe." When each example is worked out according to the schedule, the result is as follows:

	Wk. C.	Wks.	Tl. Comp.	Wk. C.	Wks.	Tl. Comp.	Wk. C.	Wks.	Tl. Comp
Exam. 5..	$19.50×	297 =	$5791.50	$19.50×	329 =	$6415.50	$19.50×	364 =	$7098.00
Exam. 7..	19.50×	278 =	5421.00	19.50×	313 =	6103.50	19.50×	346 =	6747.00
Difference		19	$ 370.50		16	$ 312.00		18	$ 351.00

[70] No reason is given why 65% of the weekly wages is taken as a compensation, or why it cannot exceed $20.83 or be less than $4.17, or why there is any need of enumerating 1,107 different occupations when so many of them are so nearly identical that there is no sense in making a distinction for economic purposes.

[71] In Table I, in giving the nature of the disability "the ability to compete" is mentioned in its true sense, but "the ability to compete" is not mentioned in connection with the examples given, by which the application of the schedule is made to illustrate how the compensation is obtained. However, a way to obtain the damage to the competing ability to a certain extent is incorporated in the series of tables that constitute an important part of the schedule and it is to the credit of the originator of this schedule that "the ability to compete" is recognized in it, for this factor of the earning ability of a person is foreign to most empirical methods.

[72] The indisputable fact about the compensation problem is that it must be solved on the basis of the loss to the earning ability of a person, if an exact mathematical determination of it is to be made according to the natural science method between the two cardinal points of no loss to total loss, or 100% loss to it. Therefore, the different values in percentage thus determined constitute these tables. They are all embracing and yet flexible enough to meet every individual loss to the earning ability of a person that can possibly occur from injury or disease. Hence, they should be accepted by those who

approach the solution of this subject with an open mind, for they can just as readily be used as any that are obtained by empirical methods.

[73] If the three degrees of loss to the earning ability for slight, severe, nearly total and total loss to the functional ability of the body for the partial or complete loss of the function of vision do not seem equitable to the medical examiner, he of course can select any one of the sixteen different degrees of loss to the earning ability of the body found in Tables 3 and 4, which he determines to be more equitable for the particular case in hand.

[74] Should he determine from all the circumstances of a case that one of the sixteen degrees of loss to the earning ability was too small, and the next degree was too much, he can add the two together thus: For the loss of the functions of one eye:

32.76 Se. 2° + 44.87 Se. 3° = 77.63 ÷ 2 = 38.81½% (half way between Se. 2° and Se. 3°).

This adding of contiguous degrees of the sixteen degrees in Tables 3 and 4 gives 32 degrees from which to select a percentage of loss to the earning ability of the body for any given loss of the functions of an eye or the eyes, or the loss of the functions of any other system or organ of the body that may have taken place at the same time. If it is desired to carry this process further, the half-way percentage may be added to the contiguous percentages by which it was ascertained, and thus obtain a fourth and a three-fourths way percentage of loss to the earning ability of the body, as follows:

$$(1)\quad \begin{array}{r} 32.76 \\ 38.81\tfrac{1}{2} \\ \hline 2\overline{)71.57\tfrac{1}{2}} \\ 35.78\tfrac{3}{4}\% \end{array} \qquad\qquad (2)\quad \begin{array}{r} 44.87 \\ 38.81\tfrac{1}{2} \\ \hline 2\overline{)83.68\tfrac{1}{2}} \\ 41.84\tfrac{1}{4}\% \end{array}$$

Thus (1) is one-fourth the way between Se. 2° and Se. 3°, and (2) is three-fourths of the way between these two degrees, making three different degrees in percentage between Se. 2° and Se. 3°, as follows:

32.76; 35.78¾; 38.81½; 41.84¼; 44.87.

This can be done with any two of the sixteen contiguous degrees of loss to the earning ability in Tables 3 and 4, making 64 different degrees between two fixed points of slight loss and nearly total loss to the earning ability, a range and gradation sufficient to meet any loss to it that can be determined by the most exact examination with instruments and methods of precision, standards of measurement, and all other data that it is possible for any number of medical examiners to carry out in any given case. These procedures are permissible if it is determined to be necessary because the examiner can state just how he arrived at the percentage of loss he determined upon and his reasons for so doing. Every step of the whole procedure can be taken up and discussed with each medical examiner whether it be the func-

[75] COMPUTATION TABLE NO. 1 AND 2—Status of E, the Earning Body, with Its Consequent Damage to C, the Competing Ability of the

Computations made when C is damaged from 2 to 9 degrees more than F.

NEARLY TOTAL					SEVERE			
5° C^{10} E =	4° C^{9} E=	3° C^{8} E =	2° C^{7} E =	1° C^{6} E =	6° C^{5} E =	5° C^{4} E =	4° C^{3} E =	3° C^{2} E =
.8946	.9037	.9129	.9222	.9316	.9411	.9507	.9604	.9702
.8002	.8166	.8333	.8504	.8678	.8856	.9037	.9222	.9411
.7149	.7371	.7599	.7835	.8078	.8328	.8586	.8852	.9126
.6379	.6645	.6922	.7211	.7512	.7826	.8153	.8493	.8847
.5684	.5984	.6299	.6631	.6981	.7349	.7736	.8144	.8573
.5060	.5383	.5727	.6093	.6482	.6896	.7337	.7806	.8305
.4541	.4883	.5201	.5593	.6015	.6468	.6955	.7479	.8043
.3949	.4293	.4667	.5073	.5576	.6061	.6589	.7163	.7786
.3359	.3892	.4277	.4700	.5165	.5676	.6238	.6856	.7535
.3134	.3483	.3871	.4302	.4781	.5313	.5904	.6561	.729
.2772	.3115	.3500	.3933	.4420	.4967	.5582	.6273	.7049
.2447	.2781	.3161	.3593	.4084	.4642	.5276	.5996	.6814
.2158	.2481	.2852	.3279	.3770	.4334	.4982	.5727	.6585
.1862	.2166	.2519	.2990	.3477	.4044	.4703	.5469	.6360
.1671	.1966	.2314	.2723	.3204	.377	.4436	.5219	.6141
.1468	.1748	.2081	.2478	.295	.3512	.4181	.4978	.5927
.1299	.1566	.1867	.225	.2712	.3268	.3938	.4745	.5717
.1125	.1372	.1674	.2042	.2491	.3038	.3706	.4520	.5513
.0983	.1214	.1499	.1851	.2286	.2823	.3486	.4304	.5314
.0859	.1072	.134	.1676	.2096	.2620	.3276	.4096	.512
.0746	.0945	.1197	.1516	.1919	.2430	.3076	.3894	.4930
.0648	.0832	.1067	.1368	.1755	.2251	.2886	.3701	.4745
.0562	.0731	.095	.1234	.1603	.2083	.2706	.3515	.4565
.0487	.0641	.0844	.1111	.1463	.1925	.2534	.3335	.4389
.0421	.0562	.075	.1000	.1334	.1779	.2372	.3163	.4218
.0363	.0491	.0664	.0898	.1214	.1641	.2218	.2998	.4052
.0312	.0428	.0587	.0805	.1103	.1512	.2072	.2839	.3890
.0268	.0373	.0519	.0721	.1002	.1392	.1934	.2687	.3732
.023	.0324	.0457	.0644	.0908	.1280	.1804	.2541	.3579
.0197	.0282	.0403	.0576	.0823	.1176	.168	.2401	.343
.0167	.0243	.0353	.0512	.0743	.1078	.1563	.2266	.3285
.0142	.0210	.031	.0456	.0671	.0988	.1453	.2137	.3144
.0121	.0181	.0271	.0405	.0605	.0903	.1349	.2014	.3007
.0102	.0155	.0236	.0359	.0544	.0825	.1251	.1896	.2874
.0086	.0133	.0206	.0317	.0489	.0753	.1159	.1784	.2746
.0072	.0114	.0179	.028	.0439	.0686	.1073	.1677	.2621
.0061	.0097	.0155	.0247	.0393	.0624	.0992	.1575	.2500
.0051	.0083	.0134	.0217	.0351	.0567	.0915	.1477	.2383
.0042	.007	.0115	.019	.0313	.0514	.0844	.1384	.2269
.0036	.006	.01	.0167	.0279	.0466	.0777	.1296	.216
10	9	8	7	6	5	4	3	2

tions of one organ like the eye that is involved in the loss to the earning ability from injury or disease, or whether it be the functions of several other systems and organs of the body that are involved in the loss from the same injury or disease.

Ability of the Body from Loss to F, the Functional Ability of the Body in Sixteen Different Degrees.

Computations made when C is damaged to the same degree as F and when C is damaged to 6 different degrees less than F.

SEVERE				SLIGHT				
Loss to F	Status F & C	2° $C^{1}E =$	1° $C^{1/2} E =$	5° $C^{1/3} E =$	4° $C^{1/4} E =$	3° $C^{1/5} E =$	2° $C^{1/7} E =$	1° $C^{1/10} E =$
.01	.99 × .99	.9801	.985	.9865	.9875	.988	.9885	.989
.02	.98 × .98	.9604	.9702	.9731	.9751	.976	.977	.978
.03	.97 × .97	.9409	.9554	.9593	.9622	.9641	.9651	.967
.04	.96 × .96	.9216	.9408	.9465	.9504	.9523	.9542	.9561
.05	.95 × .95	.9025	.9262	.9338	.9376	.9405	.9424	.9452
.06	.94 × .94	.8836	.9118	.9202	.9259	.9277	.9315	.9343
.07	.93 × .93	.8649	.8965	.9067	.9132	.9151	.9197	.9234
.08	.92 × .92	.8464	.8822	.8942	.9006	.9043	.9089	.9126
.09	.91 × .91	.8281	.8681	.8808	.8881	.8927	.8972	.9001
.10	.90 × .90	.81	.8541	.8676	.8766	.8811	.8865	.8901
.11	.89 × .89	.7921	.8392	.8552	.8641	.8695	.8748	.8784
.12	.88 × .88	.7744	.8254	.843	.8527	.858	.8641	.8685
.13	.87 × .87	.7569	.8108	.8308	.8404	.8456	.8526	.8578
.14	.86 × .86	.7396	.7972	.8187	.8290	.8342	.8419	.8471
.15	.85 × .85	.7225	.7828	.8058	.8160	.8228	.8304	.8347
.16	.84 × .84	.7056	.7694	.7929	.8047	.8114	.819	.8257
.17	.83 × .83	.6889	.7561	.7802	.7885	.7992	.8075	.8142
.18	.82 × .82	.6724	.7429	.7675	.7806	.788	.797	.8036
.19	.81 × .81	.6561	.729	.7549	.7686	.7759	.7857	.7929
.20	.80 × .80	.64	.7152	.7424	.7568	.7648	.7752	.7824
.21	.79 × .79	.6241	.7015	.7299	.7449	.7528	.7639	.7710
.22	.78 × .78	.6084	.6887	.7183	.7332	.7417	.7527	.7605
.23	.77 × .77	.5929	.6752	.7060	.7214	.7299	.7415	.7499
.24	.76 × .76	.5776	.6627	.6938	.7098	.7189	.7303	.7394
.25	.75 × .75	.5625	.6495	.6817	.6982	.7072	.7192	.7282
.26	.74 × .74	.5476	.6371	.6697	.6867	.6963	.7089	.7178
.27	.73 × .73	.5329	.6241	.6577	.6752	.6847	.6978	.7073
.28	.72 × .72	.5184	.6112	.6458	.6638	.6739	.6868	.6969
.29	.71 × .71	.5041	.5985	.6340	.6517	.6624	.6759	.6858
.30	.70 × .70	.49	.5859	.6223	.6405	.6517	.6650	.6755
.31	.69 × .69	.4761	.5733	.6099	.6285	.6403	.6541	.6679
.32	.68 × .68	.4624	.561	.5984	.6174	.6296	.6432	.6541
.33	.67 × .67	.4489	.5487	.5862	.6056	.6184	.6324	.6432
.34	.66 × .66	.4356	.5365	.5748	.5946	.6078	.6217	.6329
.35	.65 × .65	.4225	.5239	.5629	.5830	.5967	.611	.622
.36	.64 × .64	.4096	.512	.5516	.5721	.5856	.6003	.6118
.37	.63 × .63	.3969	.4995	.5399	.5607	.5745	.5896	.601
38	.62 × .62	.3844	.4879	.5288	.5499	.5635	.5790	.5908
.39	.61 × .61	.3721	.4758	.5172	.5386	.5526	.5685	.5801
.40	.60 × .60	.36	.4644	.5058	.5280	.5418	.5580	.5700
1	2 3	4	5	6	7	8	9	10

[76] Computation Tables No. 3 and 4—Loss to E, the Earning Body with Its Consequent Damage to C, the Competing Ability of the

Computations showing the loss on $1.00 when C is damaged from 2 to 9 degrees more than F.

NEARLY TOTAL					SEVERE			
5° C^{10} E =	4° C^{9} E =	3° C^{8} E =	2° C^{7} E =	1° C^{6} E =	6° C^{5} E =	5° C^{4} E =	4° C^{3} E =	3° C^{2} E =
%	%	%	%	%	%	%	%	%
10.54	9.61	8.71	7.78	6.84	5.89	4.93	3.96	2.98
19.98	18.34	16.67	14.96	13.22	11.44	9.63	7.78	5.85
28.51	26.29	24.01	21.65	19.22	16.72	14.14	11.48	8.74
36.21	33.55	30.78	27.89	24.88	21.74	18.47	15.07	11.53
43.16	40.16	37.01	33.69	30.19	26.51	22.64	18.56	14.27
49.40	46.17	42.73	39.07	35.18	31.04	26.63	21.94	16.95
54.59	51.17	47.99	44.07	39.85	35.32	30.45	25.21	19.57
60.51	57.07	53.33	49.27	44.24	39.39	34.11	28.37	22.14
66.41	61.08	57.23	53.00	48.35	43.24	37.62	31.44	24.65
68.66	65.17	61.29	56.98	52.19	46.87	40.96	34.39	27.10
72.28	68.85	65.00	60.67	55.80	50.33	44.18	37.27	29.51
75.53	72.19	68.39	64.07	59.16	53.58	47.24	40.04	31.86
78.42	75.19	71.48	67.21	62.30	56.66	50.18	42.73	34.15
81.38	78.34	74.81	70.10	65.23	59.56	52.97	45.31	36.40
83.29	80.34	76.86	72.77	67.96	62.30	55.64	47.81	38.59
85.32	82.52	79.19	75.22	70.50	64.88	58.19	50.22	40.73
87.01	84.34	81.33	77.50	72.88	67.32	60.62	52.55	42.83
88.75	86.28	83.26	79.58	75.09	69.62	62.94	54.80	44.87
90.17	87.86	85.01	81.49	77.14	71.77	65.14	56.96	46.86
91.41	89.28	86.60	83.24	79.04	73.80	67.24	59.04	48.80
92.54	90.55	88.03	84.84	80.81	75.70	69.24	61.06	50.70
93.52	91.68	89.33	86.32	82.45	77.49	71.14	62.99	52.55
94.38	92.69	90.50	87.66	83.97	79.17	72.94	64.85	54.35
95.13	93.59	91.56	88.89	85.37	80.75	74.66	66.65	56.11
95.79	94.38	92.50	90.00	86.66	82.21	76.28	68.37	57.82
96.37	95.09	93.36	91.02	87.86	83.59	77.82	70.02	59.48
96.88	95.72	94.13	91.95	88.97	84.88	79.28	71.61	61.10
97.32	96.27	94.81	92.79	89.98	86.08	80.66	73.13	62.68
97.70	96.76	95.43	93.56	90.92	87.20	81.96	74.59	64.21
98.03	97.18	95.97	94.24	91.77	88.24	83.20	75.99	65.70
98.33	97.57	96.47	94.88	92.57	89.22	84.37	77.34	67.15
98.58	97.90	96.90	95.44	93.29	90.12	85.47	78.63	68.56
98.79	98.19	97.29	95.95	93.95	90.97	86.51	79.86	69.93
98.98	98.45	97.64	96.41	94.56	91.75	87.49	81.04	71.26
99.14	98.67	97.94	96.83	95.11	92.47	88.41	82.16	72.54
99.28	98.86	98.21	97.20	95.61	93.14	89.27	83.21	73.79
99.39	99.03	98.45	97.53	96.07	93.76	90.08	84.25	75.00
99.49	99.17	98.66	97.83	96.49	94.33	90.85	85.23	76.17
99.58	99.30	98.85	98.10	96.87	94.86	91.56	86.16	77.31
99.64	99.40	99.00	98.33	97.21	95.34	92.23	87.04	78.40
10	9	8	7	6	5		3	2

Ability of the Body from Loss to F, the Functional Ability of the Body, in Sixteen Different Degrees.

Computations showing the loss on $1.00 when C is damaged to the same degree as F and when C is damaged to 6 different degrees less than F.

SEVERE				SLIGHT				
Loss to F	Status F & C	2° C^1 E=	1° $C^{1/2}$ E=	5° $C^{1/3}$ E=	4° $C^{1/4}$ E=	3° $C^{1/5}$ E=	2° $C^{1/7}$ E=	1° $C^{1/10}$E=
		%	%	%	%	%	%	%
.01	.99×.99	1.99	1.50	1.35	1.25	1.20	1.15	1.10
.02	.98×.98	3.96	2.98	2.69	2.49	2.40	2.30	2.20
.03	.97×.97	5.91	4.46	4.07	3.78	3.59	3.49	3.30
.04	.96×.96	7.84	5.92	5.35	4.96	4.77	4.58	4.39
.05	.95×.95	9.75	7.38	6.62	6.24	5.95	5.76	5.48
.06	.94×.94	11.64	8.82	7.98	7.41	7.23	6.85	6.57
.07	.93×.93	13.51	10.35	9.33	8.68	8.49	8.03	7.66
.08	.92×.92	15.36	11.78	10.58	9.94	9.57	9.11	8.74
.09	.91×.91	17.19	13.19	11.92	11.19	10.73	10.28	9.99
.10	.90×.90	19.00	14.59	13.24	12.34	11.89	11.35	10.99
.11	.89×.89	20.79	16.08	14.48	13.59	13.05	12.52	12.16
.12	.88×.88	22.56	17.46	15.70	14.73	14.20	13.59	13.15
.13	.87×.87	24.31	18.92	16.92	15.96	15.44	14.74	14.22
.14	.86×.86	26.04	20.28	18.13	17.10	16.58	15.81	15.29
.15	.85×.85	27.75	21.72	19.42	18.40	17.72	16.96	16.53
.16	.84×.84	29.44	23.06	20.74	19.53	18.86	18.10	17.43
.17	.83×.83	31.11	24.39	21.98	21.15	20.08	19.25	18.58
.18	.82×.82	32.76	25.71	23.25	21.94	21.20	20.30	19.64
.19	.81×.81	34.39	27.10	24.51	23.14	22.41	21.43	20.71
.20	.80×.80	36.00	28.48	25.76	24.32	23.52	22.48	21.76
.21	.79×.79	37.59	29.85	27.01	25.51	24.72	23.61	22.90
.22	.78×.78	39.16	31.13	28.17	26.68	25.83	24.73	23.95
.23	.77×.77	40.71	32.48	29.40	27.86	27.01	25.85	25.01
.24	.76×.76	42.24	33.73	30.62	29.02	28.11	26.97	26.06
.25	.75×.75	43.75	35.05	31.83	30.18	29.28	28.08	27.18
.26	.74×.74	45.24	36.29	33.03	31.33	30.37	29.11	28.22
.27	.73×.73	46.71	37.59	34.23	32.48	31.53	30.22	29.27
.28	.72×.72	48.16	38.88	35.42	33.62	32.61	31.32	30.31
.29	.71×.71	49.59	40.15	36.60	34.83	33.76	32.41	31.35
.30	.70×.70	51.00	41.41	37.77	35.95	34.83	33.50	32.45
.31	.69×.69	52.39	42.67	39.01	37.15	35.97	34.59	33.49
.32	.68×.68	53.76	43.90	40.16	38.26	37.04	35.68	34.59
.33	.67×.67	55.11	45.13	41.38	39.44	38.16	36.76	35.68
.34	.66×.66	56.44	46.35	42.52	40.54	39.22	37.83	36.71
.35	.65×.65	57.75	47.61	43.71	41.70	40.33	38.90	37.80
.36	.64×.64	59.04	48.80	44.84	42.79	41.44	39.97	38.82
.37	.63×.63	60.31	50.05	46.01	43.93	42.55	41.04	39.90
.38	.62×.62	61.56	51.21	47.12	45.01	43.65	42.10	40.92
.39	.61×.61	62.79	52.42	48.28	46.14	44.74	43.15	41.99
.40	.60×.60	64.00	53.56	49.42	47.20	45.82	44.20	43.00
1	2 3	4	5	6	7	8	9	10

[77] Table No. 5—Standard of Measurement for Determining the Loss to F, the Functional Ability of the Body, for the Partial or Complete Loss in the Functions of the Joints of the Body from Ankylosis; for the Loss of the Functions of the Muscles from any Cause; and for the Loss of the Functions of the Parts of the Body from Amputation.

Loss to F (a) from Ankylosis of the				Loss to F (a) from Amputation of the			
Fingers		Toes		Fingers		Toes	
Little	0.01	Little	0.005	Little	0.01	Little	0.005
Ring	0.02	Fourth	0.005	Ring	0.02	Fourth	0.005
Middle	0.02	Middle	0.005	Middle	0.03	Middle	0.01
Index	0.02	Second	0.005	Index	0.04	Second	0.01
Thumb	0.03	Big	0.01	Thumb	0.05	Big	0.02
Wrist	0.10	Ankle	0.10	Hand	0.20	Foot	0.20
Elbow	0.15	Knee	0.15	Forearm	0.25	Leg	0.25
Shoulder	0.15	Hip	0.15	Arm	0.30	Thigh	0.30

[78] Eye Table No. 1, Part 1, partial or complete loss of vision in one eye gives the standard of measurement for the loss of vision (V) in one eye for a slight, a severe, a nearly total and a total loss of vision, designated by proper and decimal fractions, according to the scientific standard of measurement of Snellen, giving the average loss to F, the functional ability of the body, in each one of the four degrees of its loss, in one column, which constitutes the key to Tables 3 and 4, by which the sixteen different computations may be readily found and from which may be selected a minimum, a medium and a maximum percentage of loss to the earning ability as determined upon from all the circumstances of each individual case. Then the loss to F, and C, the competing ability of the body, is given, which constitutes the loss to E, the earning ability of the body, which is also given for the purpose of illustrating the loss in a minimum %, a medium %, and a maximum % of loss to it, and designated by the character of the loss and a figure with the sign of degree indicating the degree of loss and the column from whence it was taken out of the sixteen computations which have been worked out in *Physical Economics* in Tables 3 and 4, according to the natural science method.

[79] Part 2, partial or complete loss of vision in both eyes, gives all the different combinations of loss to F, the functional ability of the body in one column; then the loss to F and C, or E, in percentage in three degrees designated by the character of the loss and a figure with the sign of degree indicating the degree of loss and the column from whence it was taken out of the sixteen computations of Tables 3 and 4.

[80] Eye Table No. 2, Part 1, partial or complete loss of the field of vision of one eye gives the standard of measurement for the loss

of the field of vision (Fd.) in one eye, for a slight, a severe, a nearly total and a total loss of the field of vision, measured by the degrees of loss, designated in decimal and proper fractions, giving the average loss to F, the functional ability of the body, in each one of the four degrees of its loss in one column, which is the key to Tables 3 and 4, by which the sixteen different computations may be readily found. The loss to F and C, the competing ability of the body, is then given, which constitutes the loss to E, the earning ability of the body, which is also given for the purpose of illustration, in a minimum %, a medium %, and a maximum % of loss to the earning ability of the body, and designated by the character of the loss and a figure with the sign of degree indicating the degree of loss and the column from whence it was taken out of the sixteen computations in Tables 3 and 4.

[81] For the average loss to F, the functional ability of the body, in this table of .015, .045, and .075, there is no computation in Tables 3 and 4, but the value may be found by adding together the two contiguous computations. Thus for .015 we add that for .01 and .02; thus, $1.10 + 2.20 = 3.30 \div 2 = 1.65$, and for the other two fractions in the same way ¶ 74.

[82] Part 2, partial or complete loss of the field of vision of both eyes is nearly the same as in Part 1, after the slight loss; but the loss to F, the functional ability of the body, is much greater, because it diminishes the field of vision of both eyes at the same time and thereby quadruples the loss for each of the four degrees.

[83] Eye Table No. 3, Part 1, partial or complete loss of muscular functions of one eye for the different degrees of slight, severe and nearly total loss presents difficulties not encountered in the other two tables in that a slight loss in the muscular functions may produce nearly total loss of the functions of vision of one eye.

For instance, a slight loss in the action of a muscle relative to the range of its complete action might occur in heterotropia or paresis causing diplopia and such strain to the eyes that it would produce a severe, or a nearly total loss of the functions of the eyes and damage that person, if it could not be remedied, in his competing ability to a severe or to a nearly total degree, and thereby cause a corresponding loss to the earning ability of that person, for the loss of the functions of one eye.

[84] The supreme importance of solving the problem of physical economics, and hence visual economics, by the natural science method is that it determines the loss to the earning ability of the body, upon which compensations must be based, in accordance with the exact existing conditions of its indispensable factors by the use of instru-

ments and methods of precision, standards of measurement and other data, and the employment of two fixed mathematical laws, by which the damage to the competing ability from the loss to the functional ability of the body from .01 to .80 is graded between two cardinal points of no loss to total or 100% loss, thus giving sixteen different degrees of loss to the earning ability of the body, a range and gradation sufficient to determine a compensation for the loss to it from any injury or disease that could possibly happen to a person.

[85] Eye Table No. 1, Part 1. Partial or Complete Loss of the Function of Vision of One Eye.

Standard of Measurement for the Loss of the Function of Vision (V) of One Eye. F (g).

Slight (St.) from	Severe (Sc.) from	Nearly total (Nt.) from	Total (Tl.) from
20/25 to 20/35	20/40 to 20/55	20/60 to 20/180	20/200 to 0
(0.8 to 0.6+)	(0.5 to 0.3—)	(0.3 to 0.1+)	(0.1 to 0)
Average loss to F = .03	Average loss to F = .09	Average loss to F = .15	Average loss to F = .18

		Min. percent	Med. percent	Max. percent
(1)	St. loss of V. loss to F = .03; F×C or E =	3.30 (St.1°)	3.59 (St.3°)	4.07 (St.5°)
(2)	Sc. loss of V. loss to F = .09; F×C or E =	10.73 (St.3°)	11.92 (St.5°)	13.19 (Sc.1°)
(3)	Nt. loss of V. loss to F = .15; F×C or E =	17.72 (St.3°)	19.42 (St.5°)	27.75 (Sc.2°)
(4)	Tl. loss of V. loss to F = .18; F×C or E =	32.76 (Sc.2°)	44.87 (Sc.3°)	54.80 (Sc.4°)

Part 2. Partial or Complete Loss of the Function of Vision of Both Eyes.

		Min. percent	Med. percent	Max. percent
(5)	St. with St. loss to F = .06; F×C or E =	6.57 (St.1°)	7.23 (St.3°)	7.98 (St.5°)
(6)	St. with Sc. loss to F = .12; F×C or E =	13.15 (St.1°)	15.70 (St.5°)	17.46 (Sc.1°)
(7)	St. with Nt. loss to F = .18; F×C or E =	19.64 (St.1°)	23.25 (St.5°)	25.71 (Sc.1°)
(8)	St. with Tl. loss to F = .21; F×C or E =	37.59 (Sc.2°)	50.70 (Sc.3°)	61.06 (Sc.4°)
(9)	Sc. with Sc. loss to F = .18; F×C or E =	25.71 (Sc.1°)	32.76 (Sc.2°)	44.87 (Sc.3°)
(10)	Sc. with Nt. loss to F = .24; F×C or E =	33.73 (Sc.1°)	42.24 (Sc.2°)	56.11 (Sc.3°)
(11)	Sc. with Tl. loss to F = .27; F×C or E =	46.71 (Sc.2°)	61.10 (Sc.3°)	71.61 (Sc.4°)
(12)	Nt. with Nt. loss to F = .30; F×C or E =	51.00 (Sc.2°)	65.70 (Sc.3°)	75.99 (Sc.4°)
(13)	Nt. with Tl. loss to F = .33; F×C or E =	55.11 (Sc.2°)	69.93 (Sc.3°)	79.86 (Sc.4°)
(14)	Tl. with Tl. loss to F = .36; F×C or E =	59.04 (Sc.2°)	73.79 (Sc.3°)	100.

[86] Eye Table No. 2, Part 1. Partial or Complete Loss of the Function of the Field of Vision of One Eye.

Standard of Measurement for the Loss of the Function of the Field of Vision (Fd.) of One Eye. F (g).

Slight (St.)	Severe (Se.)	Nearly total (Nt.)	Total (Tl.)
from 150° to 120°	from 120° to 60°	from 60° to 15°	from 15° to 0
(from 1 to .8)	(from .8 to .4)	(from .4 to .1)	(from .1 to 0)
(from 1 to 4/5)	(from 4/5 to 2/5)	(from 2/5 to 1/10)	(from 1/10 to 0)
Average loss to F = .015	Average loss to F = .045	Average loss to F = .075	Average loss to F = .09

		Min. percent	Med. percent	Max. percent
(1)	St. loss in Fd. loss to F = .015; F×C or E =	1.65 (St.1°)	1.80 (St.3°)	2.02 (St.5°)
(2)	Se. loss in Fd. loss to F = .045; F×C or E =	4.93 (St.1°)	5.36 (St.3°)	5.98 (St.5°)
(3)	Nt. loss in Fd. loss to F = .075; F×C or E =	7.11 (St.1°)	7.86 (St.3°)	8.65 (St.5°)
(4)	Tl. loss in Fd. loss to F = .090; F×C or E =	10.73 (St.3°)	11.19 (St.5°)	17.19 Se(.2°)

Part 2. Partial or Complete Loss of the Function of the Field of Vision of Both Eyes.

Standard of Measurement for the Loss of the Function of the Field of Vision (Fd.) of Both Eyes. F (g).

Slight (St.)	Severe (Se.)	Nearly total (Nt.)	Total (Tl.)
from 180° to 120°;	from 120° to 60°;	from 60° to 15°;	from 15° to 0
(from 1 to 2/3);	(from 2/3 to 1/3);	(from 1/3 to 1/12);	(from 1/12 to 0)
Av. loss to F = .06;	Av. loss to F=18;	Av. loss to F = .30;	Av. loss to F = .36

		Min. percent	Med. percent	Max. percent
(5)	St. loss in Fd. loss to F = .06; F×C or E =	7.23 (St.3°)	8.82 (Se.1°)	11.64 (Se.2°)
(6)	Se. loss in Fd. loss to F = .18; F×C or E =	21.20 (St.3°)	25.71 (Se.1°)	32.76 (Se.2°)
(7)	Nt. loss in Fd. loss to F = .30; F×C or E =	37.77 (St.5°)	41.41 (Se.1°)	51.00 (Se.2°)
(8)	Tl. loss in Fd. loss to F = .36; F×C or E =	59.04 (Se.2°)	73.79 (Se.3°)	83.21 (Se.4°)
(9)	Right homonymous hemianopsia, loss to F = .18; F×C or E = (1)	54.80 (Se.4°)	62.94 (Se.5°)	75.09 (Nt.1°)
(10)	Left homonymous hemianopsia, loss to F = .18; F×C or E =	44.87 (Se.3°)	54.80 (Se.4°)	62.94 (Se.5°)
(11)	Inferior hemianopsia, loss to F = .18; F×C or E =	54.80 (Se.4°)	62.94 (Se.5°)	75.09 (Nt.1°)
(12)	Superior hemianopsia, loss to F = .18; F×C or E =	44.87 (Se.3°)	54.80 (Se.4°)	62.94 (Se.5°)

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(1) In the experience of the author all persons are practically totally disabled with hemianopsia of either kind.

[87] Eye Table No. 3, Part 1. Partial or Complete Loss of Muscular Functions of One Eye.

Standard of Measurement for the Loss of Muscular Functions (Mf.) of One Eye. F (g).

St.Av.loss to F = .03; Se.Av.loss to F = .09; Nt.Av.loss to F = .15; Tl.Av.loss to F = .18.

St. loss occurs in	Heterophorias P. R. and in A.; paresis and paralysis, slight and without diplopia; ophthalmoplegia interna slight; lagophthalmus slight.
Se. loss occurs in	Heterotropia without diplopia; paresis and paralysis without diplopia; ophthalmoplegia interna severe; lagophthalmus severe and irremediable.
Nt. loss occurs in	Heterotropia with diplopia, necessitating exclusion of the eye. Paresis and paralysis, necessitating exclusion of the eye. Ophthalmoplegia externa, necessitating exclusion of the eye. Ophthalmoplegia interna, necessitating exclusion of the eye. Lagophthalmus complete, necessitating exclusion of the eye.
Tl. loss occurs in	Affections enumerated under the head of Nearly Total Loss when vision has been lost to a nearly total degree or to a Total Loss.

	Min. Percent	Med. Percent	Max. Percent
(1) St. loss of Mf.(Av. loss to F=.03; F×C or E) =	3.3 (St.1°)	3.59 (St.3°)	4.07 (St.5°)
(2) Se. loss of Mf. (Av. loss to F=.09; F×C or E) =	9.99 (St.1°)	10.73 (St.3°)	11.92 (St.5°)
(3) Nt. loss of Mf. (Av. loss to F=.15; F×C or E) =	16.96 (St.2°)	19.42 (St.5°)	21.72 (Se.1°)
(4) Tl. loss of Mf. (Av. loss to F=.18; F×C or E) =	32.76 (Se.2°)	44.87 (Se.3°)	54.80 (Se.4°)

Eye Table No. 3, Part 2. Partial or Complete Loss of Muscular Functions of Both Eyes.

	Min. Percent	Med. Percent	Max. Percent
(5) St. with St. (Av. loss to F = .06; F×C or E) =	6.57 (St.1°)	7.23 (St.3°)	7.98 (St.5°)
(6) St. with Se. (Av. loss to F = .12; F×C or E) =	(13.15 (St.1°)	15.70 (St.5°)	17.46 (Se.1°)
(7) St. with Nt. (Av. loss to F = .18; F×C or E) =	19.64 (St.1°)	21.20 (St.3°)	25.71 (Se.1°)
(8) St. with Tl. (Av. loss to F = .21; F×C or E) =	29.85 (Se.1°)	50.70 (Se.3°)	61.06 (Se.4°)
(9) Se. with Se. (Av. loss to F = .18; F×C or E) =	25.71 (Se.1°)	32.76 (Se.2°)	44.87 (Se.3°)
(10) Se. with Nt. (Av. loss to F = .24; F×C or E) =	33.73 (Se.1°)	42.24 (Se.2°)	56.11 (Se.3°)
(11) Se. with Tl. (Av. loss to F = .27; F×C or E) =	37.59 (Se.1°)	61.10 (Se.3°)	71.61 (Se.4°)
(12) Nt. with Nt. (Av. loss to F = .30; F×C or E) =	41.41 (Se.1°)	65.70 (Se.3°)	75.99 (Se.4°)
(13) Nt. with Tl. (Av. loss to F = 33;. F×C or E) =	45.13 (Se.1°)	69.93 (Se.3°)	79.86 (Se.4°)
(14) Tl. with Tl. (Av. loss to F = .36; F×C or E) =	59.04 (Se.2°)	73.79 (Se.3°)	83.21 (Se.4°)

[88] Ear Table. Part 1. Partial or Complete Loss of the Function of Hearing in One Ear.

Standard of Measurement for the Loss of the Function of Hearing (H) in One Ear. F (g).

Slight (St.) from 6/6 to 5/6+	Severe (Se.) from 4/6 to 3/6+	Nearly Total (Nt.) from 2/6 to 1/6—	Total (Tl.) from 1/6— to 0
Average loss to F = .02	Average loss to F = .06	Average loss to F = .10	Average loss to F = .12

		Min. Percent	Med. Percent	Max. Percent
(1)	St. loss of H. loss to F=.02; F×C or E=	2.20 (St.1°)	2.4 (St.3°)	2.69 (St.5°)
(2)	Se. loss of H. loss to F=.06; F×C or E=	7.23 (St.3°)	7.98 (St.5°)	8.82 (Se.1°)
(3)	Nt. loss of H. loss to F=.10; F×C or E=	11.89 (St.3°)	13.24 (St.5°)	14.59 (Se.1°)
(4)	Tl. loss of H. loss to F=.12; F×C or E=	15.70 (St.5°)	17.46 (Se.1°)	22.56 (Se.2°)

Part 2. Partial or Complete Loss of the Function of Hearing in Both Ears.

			Min. Percent	Med. Percent	Max. Percent
(5)	St. with St.	loss to F=.04; F×C or E=	4.39 (St.1°)	4.77 (St.3°)	5.35 (St.5°)
(6)	St. with Se.	loss to F=.08; F×C or E=	10.58 (St.5°)	11.78 (Se.1°)	15.36 (Se.2°)
(7)	St. with Nt.	loss to F=.12; F×C or E=	15.70 (St.5°)	17.46 (Se.1°)	22.56 (Se.2°)
(8)	St. with Tl.	loss to F=.14; F×C or E=	18.13 (St.5°)	20.28 (Se.1°)	26.04 (Se.2°)
(9)	Se. with Se.	loss to F=.12; F×C or E=	17.46 (Se.1°)	22.56 (Se.2°)	31.86 (Se.3°)
(10)	Se. with Nt.	loss to F=.16; F×C or E=	23.06 (Se.1°)	29.44 (Se.2°)	40.73 (Se.3°)
(11)	Se. with Tl.	loss to F=.18; F×C or E=	25.71 (Se.1°)	32.76 (Se.2°)	44.87 (Se.3°)
(12)	Nt. with Nt.	loss to F=.20; F×C or E=	28.48 (Se.1°)	36.00 (Se.2°)	48.80 (Se.3°)
(13)	Nt. with Tl.	loss to F=.22; F×C or E=	31.13 (Se.1°)	39.16 (Se.2°)	52.55 (Se.3°)
(14)	Tl. with Tl.	loss to F=.24; F×C or E=	33.73 (Se.1°)	42.24 (Se.2°)	56.11 (Se.3°)

[89] In case of the partial or complete loss of the sight of one, or both eyes, where a person or corporation is liable for such loss, it becomes necessary to determine the economic value of the person thus damaged in order to make an equitable settlement on the basis of the earning ability of that person at the time the accident occurred. Therefore, the Table of the Economic Value of Man is added for that purpose. This table is based upon one constructed by William Farr who spent his life as superintendent of the Registrar-General's office of England

where by his writings on vital statistics and allied subjects he rendered one of the greatest services to his country and the world that ever fell to the lot of man. The values in Farr's table were converted into U. S. money and then changed to a dollar a day basis, or three hundred dollars for the full year.

[90] Table of the Economic Value of Man (Evom), is based on the premises that F, the functional ability, multiplied by T, the technical ability, multiplied by C, the competing ability, equals to E, the earning ability of the person, and that the gross economic value of man is the present value of all his earnings for a prospective working life, and the net economic value of man is the present value of all his earnings less the present value of all his personal expenses for his prospective working life.

The money values here given may be used either for the gross or for the net economic value of man, depending on whether $1 per day is the gross or the net income per day for three hundred days of the year for a prospective working life, namely $300 per year.

This table is computed on a $3\frac{1}{2}$ per cent. compound interest discount basis.

At the Age of Birth	Money Value	Annual Increase	Percentage of Increase in 5 Years	Number Living at	Number Deaths in 5 Years	Percentage of Death in 5 Years
....	133.29	....	....	513	....	....
5	1,388.44	251.03	941.66	372	141	27.48
10	2,900.98	302.50	108.94	355	17	4.57
15	4,754.26	370.65	63.88	346	9	2.53
20	5,797.72	208.69	24.05	335	11	3.17
25	6,114.51	63.35	5.46	321	14	4.17
	Decrease	Decrease	Decrease			
30	5,985.71	25.76	2.10	307	14	4.36
35	5,664.43	64.25	5.36	291	16	5.21
40	5,262.30	80.43	7.13	275	16	5.49
45	4,784.29	95.62	9.08	257	18	6.54
50	4,178.96	121.04	10.57	237	20	7.78
55	3,420.67	151.68	18.14	215	22	9.28
60	2,413.00	201.52	29.45	189	26	12.09
65	1,141.72	254.25	52.68	156	33	17.46
70	19.10	224.73	98.33	118	38	24.35
75	—609.32	125.68	—3,293.50	79	39	33.05
80	—1,017.88	81.71	—67.05	44	35	44.30

SUMMARY.

[91] Visual economics is an indispensable part of physical economics which treats of the functional ability of the eyes as an indispensable part of the functional ability of the body ¶¶ 1, 2 and 3.

[92] The functional ability of the body and the competing ability

of a person are the two indispensable factors of the earning ability, the status of which with its loss is the key to the solution of every problem in which the economic value of a person is concerned ¶¶ 4, 7 and 16.

[93] The statement of E, the earning ability of a person may be made in the natural science formula by letting F, the functional ability of the body, represent the multiplicand; and C, the competing ability of the person, represent the multiplier; thus: $F\ C = E$, the statement of the earning ability of a person for the purpose of determining its loss upon which a compensation must always be based ¶¶ 5, 6, 8, 9, 10, 16 and 72.

[94] Comparisons are made between the damages to commodities, and the damage to one or both eyes from injury or disease, to show that the principles involved in the determination of the loss to each must be identically the same if the loss to each is to be determined in a scienific manner and not estimated by empirical methods * ¶¶ 26, 33 and 84.

[95] The loss to E, the earning ability, depends upon the loss to F, the functional ability of the body, and its consequent damage to C, the competing ability of a person, in the vocation followed ¶ 4.

[96] The loss to F, the functional ability of the body, depends upon the damage to the different functions of the body from injury or disease as measured by instruments and methods of precision, scientific standards of measurement, and other data, and determines its coefficient for the factor of the multiplicand in the formula ¶¶ 11, 12, 13, 14 and 15.

[97] In order to obtain the coefficient of F, the functional ability of the body, in accordance with the natural science method, the indispensable parts of the functional ability of the body have been determined to be twelve in number, and as such are used as factors in formulas to ascertain the coefficient of the functional ability, which of course is a fraction, and as the factor of the multiplicand in the formula it is not subject to a change in value ¶¶ 11, 12, 13, 14, 75 and 76.

[98] The primary coefficient of C, the competing ability, depends for its existence upon the same identical functions of the body as F, the functional ability of the body, and therefore, must at first have the same coefficient which is called "the primary coefficient of C, the

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* Empirical methods must be used to estimate the compensation for the loss to the earning ability of a person when there has been no economic loss to the functions of the body but a damage to the competing ability of the person in the vocation followed, in the way of cosmetic defects. Empirical methods must also be used to estimate a compensation for loss in suffering of mind and body, and for punitative damages caused from injury or disease ¶¶ 2, 34 to 71.

competing ability.'' It is subject to a change in value to equitably meet the damage to it in the different vocations from the loss to the functional ability, by which any degree of a possible 100% loss to the earning ability of a person is obtained in a manner equitable to all concerned. ¶¶ 4, 15, 75 and 76.

[99] When the loss to F, the functional ability of the body, causes a greater damage to the competing ability of a person, in the vocation followed, than ''the primary coefficient of C, the competing ability,'' this coefficient must be decreased by involution to decrease its value, and thereby cause a greater damage to the competing ability and a greater loss to the earning ability of the person. ¶¶ 18, 19, 75 and 76.

[100] When the loss to F, the functional ability of the body, causes a lesser damage to the competing ability of a person, in the vocation followed, than ''the primary coefficient of C, the competing ability,'' this coefficient must be increased by evolution to increase its value and thereby cause a lesser damage to the competing ability and a lesser loss to the earning ability of the person. ¶¶ 18, 19, 75 and 76.

[101] By practicing involution and evolution ''the primary coefficient of C, the competing ability'' is graded with mathematical precision between the two cardinal points of no damage to it to total damage to it, or 100% damage to it, and thereby the loss to the earning ability of a person is graded between the two cardinal points of no loss to it, to total loss to it, or 100% loss to it, which gradation is divided into three groups and for convenience is designated slight, of which there are five degrees; severe, of which there are six degrees; and nearly total, of which there are five degrees. ¶¶ 75 and 76.

[102] The computations for grading ''the primary coefficient of C, the competing ability,'' for the loss to F, the functional ability of the body, from .01 to .40, have all been worked out, giving the status of the earning ability of a person for these losses, which constitutes Tables 1 and 2. ¶¶ 19, 20, 21, 22 and 75.

[103] Tables 3 and 4 are obtained from Tables 1 and 2, by subtracting the status of the earning ability therein given from 1, and changing the loss thus obtained to percentage. As a compensation must always be based upon the loss to the earning ability of an injured person it is only necessary to have the report of the medical examiner which gives the loss to the functional ability of the body and the degree of damage to the competing ability of the injured person, and then go direct to Tables 3 and 4, and quickly find the loss to the earning ability in percentage, upon which a compensation for that person must always be based. ¶¶ 21, 23, 24, 29, 30, 31 and 72.—(E. E. H.)

Visual field. See **Perimetry.**

Visual focus. The point at which the rays of the greatest luminous intensity (i. e., the yellow rays) are brought together by a single lens.

Visual green. A greenish pigment found in the retinal rods of frogs and some reptiles. It resembles visual purple in the higher animals, and is similar in its properties.

Visual hallucinations. See p. 5688, Vol. VIII of this *Encyclopedia.*

Visualize. To make visual or visible; to render that which is perceived only by the mind apparently visible to the eye.

Visual line. See **Visual axis.**

Visual plane. The plane including the visual axes of the eyes.

Visual purple. The photo-sensitive coloring matter of the retina. See **Rhodopsin;** also **Bleaching of the visual purple,** p. 1015, Vol. II, and **Rhodogenesis,** in this *Encyclopedia.*

Visual sound. See **Optophone,** p. 9103, Vol. XII of this *Encyclopedia.*

Visual space perception. VISUAL SPATIAL DISTURBANCES. In addition to what is said under synonymous headings herein it may be noted that Gordon Holmes (*Br. Medical Journ.,* p. 230, Aug. 23, 1919) contributes the following clear exposition of certain aspects of the subject, especially of those disturbances of spatial relations due to gunshot wounds of the brain involving the visual centers. These observations, constituting the second Montgomery Lecture, are quoted almost in full and verbatim:—

"When my eyes fall on any visible object, as on this piece of chalk on the table in front of me, I perceive it and I can in addition form certain judgments on its spatial relations to myself and to other visible objects; and if it happens to be similar to something I have seen before I can recognize its nature. That is:

"1. I can determine its position in space in relation to myself and consequently point to it if I can control and direct the movements of my arm.

"2. I can also form an appropriate estimate of its distance from me and therefore touch it if it be within my reach, or move immediately to it if it be farther from me.

"3. And if another object be within my field of vision, as this second piece of chalk, I can form an approximately correct judgment of the relative positions of the two, that is, whether the one is higher or lower, to the right or the left of, or nearer or farther than the other.

"4. When one of the objects casts its image on the periphery of my retinæ I can move my eyes so that it comes directly into central vision, and, if it is within a short distance, converge and accommodate too so that its image is focussed on my maculæ.

"5. I can estimate its size, both absolute and relative to that of other objects.

"6. I can recognize that it has thickness and depth, or in other words that it is tridimensional.

"7. Finally, I can identify it, that is, associate its visual perception with the memory images of similar or allied past impressions, and with other qualities that I have learned by previous sense experience, as weight, brittleness, etc.

"All these judgments that I can form about this piece of chalk, which has merely thrown an image on my retinæ, may be disturbed, either individually or collectively, by cerebral lesions.

"We shall consider briefly how we localize in space objects which we merely perceive by vision, and how we attain the spatial attributes with which we endow our visual perceptions. This has been the subject of much discussion. The two chief explanations are those that have been offered by the nativistic and by the empiristic hypotheses. The nativistic view attributes localization in space to innate properties of the sense organs or sensory centres, properties which are inherited and ready for use by the newly-born animal. According to the empiristic school, on the other hand, all space perception is of intellectual origin and is acquired only by habit and experience, by the testing and controlling of visual sensations by tactile, muscular, and other sensations from all parts of the body. This empiristic view is of considerable interest here, as it was first put forward more than two hundred years ago by George Berkeley in his celebrated *Essay towards a new theory of vision.*

"During the late war I was able to observe eight men with gunshot injuries of the brain who had disturbances of spatial orientation. All presented more or less similar symptoms, and as most of them remained under observation for considerable periods it was possible to investigate them repeatedly. These disturbances cannot be attributed to blindness or amblyopia, for the acuity of central vision was good in all the patients, and though there were defects in the fields of vision in several these defects bore no relation to the symptoms, which were identical in other men in whom the fields were normal. The symptoms were also unconnected with paralysis and loss of sensation, and there was no serious degree of mental deterioration in any of them. One man only had aphasia of severe degree.

Absolute localization. "The most obvious symptom was the inability of the patients to determine the position in space, in relation to themselves, of objects which they saw distinctly. When I held up a knife in front of one man he said at once 'that's a pocket-knife'; but though his eyes were directed on it he stretched out his arm in a totally wrong direction when he was told to take hold of it. Another man struck my face with his hand as he attempted to point to a pencil which I held two or three feet to my right side. Similarly when asked to pick up from a table objects which they could see and recognize, these men could never bring their hands directly to them, and often made very gross errors in their direction. One intelligent man described his experience when a meal was placed on a bed-table in front of him; when he tried to take a piece of bread he brought his hand under the table rather than above it, and on attempting to seize the cup he found his fingers first in the tea, and in his second attempt on a plate to one side of it.

"This inability to recognize the positions of objects seen was obvious whether they were in central of peripheral vision, but in the latter case the errors were much greater; most of the patients, in fact, were eventually able to localize fairly well, though not with normal accuracy, objects at which they looked.

"It was only when they relied on sight alone that they could not localize the positions of an object in space. If it touched any part of their own bodies they could always bring their hands to it immediately and correctly; touch gave them the necessary local knowledge that they failed to obtain from vision alone. This was well shown when one man was given a spoon and told to take soup from a bowl on the table in front of him; he succeeded in placing the spoon in the bowl only after repeated attempts, though he could always bring it accurately to his mouth, but when he was allowed to hold or touch the bowl with his left hand he fed himself without any difficulty. His left hand gave him the spatial information about the bowl that he could not obtain from sight alone. These patients also localized the direction of sounds as accurately as normal persons; when blindfolded they pointed in the direction of a noise, and walked towards anyone who called them, as readily and as accurately as a normal person can.

"It was the estimation of distance that was most severely affected. When the patients attempted to touch any object near to them they frequently projected their hands far beyond it; or, if it were beyond their reach, they often tried to grasp it before their hands had reached it. One man, for instance, was asked to seize a piece of paper about six yards away from him; he at once extended his right arm towards it, and continued groping for it as he approached it, and even after his hand had passed it. They were also unable to make even approximately correct estimates of the distance of objects which they saw;

a tall chimney about 500 yards distant seemed 'perhaps twenty yards' from one man—in fact, he remarked: 'Everything I see seems to be the same distance from me.'

Relative localization. "Not only were they unable to recognize the spatial relations to themselves of objects which they saw, but they could not determine accurately the relative positions of two objects that were at the same time in vision. When a silver and a copper coin, or two pieces of paper of the same size but of different color, were held up in front of them they were often unable to describe their relative positions, and especially their relative distances from themselves. They either guessed indiscriminately that the one was nearer than the other, or confessed their inability to decide. One patient, for example, could not say in which of two men, one dressed in khaki and the other in hospital blue, was the nearer when they were respectively seven and fourteen yards from him; and when he was shown a panoramic view, in which he recognized several prominent objects, he confessed that he could form no conception how they were placed in respect to one another. But when he was allowed to touch or walk to two separate objects, he no longer entertained any doubt of their relative positions.

Recognition of length and size. "Another prominent symptom in all my patients was their inability to distinguish the absolute and relative lengths and sizes of objects they were shown. They could not estimate at all accurately the length in inches or feet of a line or rod, unless it were a familiar object that they recognized. They were always uncertain which of two pencils was the longer unless the difference was considerable, and they could not divide a line accurately; in many attempts one segment was made four or five times as long as the other, yet they were generally satisfied with their attempts. They failed, too, to find the centre of a circle accurately. I asked one patient to divide a large slice of bread equally between us, but the piece he kept for himself was at least six times as large as that which he gave me, and when I pointed out that the division was unfair he failed to see it until he touched the two pieces with his fingers.

In walking. "The inability to localize objects in space by vision alone was very obvious when these patients were allowed to walk about. One man, when only a few yards from his bed, started to walk in a totally wrong direction when told to go to it, and another when asked to sit in a chair to one side of me walked up against me violently, and then explained he had no idea I was so near to him. Each was at first unable to find his way directly to any point to which he was asked to go though he saw it, or succeeded only after taking a devious route, but later most of them could go straight to a point when they kept their eyes fixed on it. In walking about they frequently collided with large obstacles, as they failed to realize their direction or their distance from themselves. Some of the men walked repeatedly up against walls, occasionally so violently as to hurt themselves, as they had no idea how near they were to them, though they saw them distinctly. One interesting feature was the difficulty they experienced in getting around obstacles which they encountered; on running into a chair, for instance, one man stood still for a moment, apparently perplexed as to how to avoid it, then shuffled to one side and when almost free back again, so that it was only after repeated attempts he succeeded in passing it. When, however, he was allowed to place his hands on it he felt his way round it at once, as easily as a normal person can in a dark room.

"All these patients had great difficulty in learning their way about. One man who was in the same small ward for three months could not, even at the end of this time, go directly to his bed, though he could see and identify it, if he had to make two or three turns on his way. Another was tested day after day in an open space divided by a partition in which there was a gate, but even after weeks of training he could rarely go straight through the gate to a point in the other division which he knew. The visual impressions out of which they would normally construct their ideas of space were devoid of spatial qualities, and this made it impossible for them to obtain clear pictures of the topography of even small areas. The topographical memory of ways and places with which they were acquainted before they were injured was also severely involved, though the patients possessed good memory pictures of things that had been familiar to them. Those who were questioned on this point were unable to say how they would find their ways about in their old haunts. One man, who had lived in a small provincial town all his life, remembered that the railway station was near his home, but he could give no idea of how he would go to it from there, or to his workshop, which he knew was close by. Another man had a vivid memory of the trenches in a sector in which he had served for a considerable time, but he had no idea of the positions of the different trenches in relation to one another, or of how to go to any point in them. Though they could describe what they passed on the way, and even the general appearance of the streets, these patients retained no idea of the relations in space of the separate objects or streets to one another.

Counting and reading. "The inability to recognize the position in regard to self of objects seen and the relative localization of several objects, as well as to retain a correct picture of the spatial relations which is normally acquired by sight, produced many other symptoms. My patients could rarely count correctly four or five similar coins or matches placed irregularly on a table in front of them. They generally turned their eyes from one to another and back again, counting and recounting till they became hopelessly confused, since they failed to recognize the mutual spatial relations of the coins and consequently had no means of distinguishing those they had already counted, as all were similar in appearance. When coins of different sizes and color were employed they could distinguish those they had already included in their tally and consequently succeeded. And as touch gave the local information that was lacking in visual impressions they counted the coins quite readily when allowed to feel them with their hands.

"The same disturbances accounted for their difficulty in reading. Though the patients could see the smallest type and recognize the written words they were often unable to read the words of a line in their proper order, and their eyes jumped irregularly from line to line, or even on to another paragraph or column. Their most constant difficulty was to find the beginning of the next line when they had finished reading the words of one. Writing was affected by the same factors. None of my patients, except one who was aphasic, had any trace of agraphia; they could write words and sentences correctly, but in the letters they attempted to write the individual words were placed so irregularly, and the lines ran so frequently across one another on the page, that the whole was scarcely intelligible.

Recognition of movement. "The appreciation of movement was accurately investigated in only one of my patients. This man was never certain whether a moving object approached or receded from him when it moved in the line of his visual axes, but he detected the slightest lateral or vertical movement and recognized its direction at once. The smallest movement could be also detected by peripheral vision, but he was always uncertain of its direction unless its range was much larger than the normal person requires for its instant recognition.

Visual attention. "Another symptom which all these patients presented was a disturbance of visual attention. Every object in central vision seemed to absorb attention, so that images which fell on the periphery of the retinæ were often unobserved; attention was incapable of noticing two or more visible objects at the same time. When the observer's hands were held up, one on each side of the patient's visual axes, he could instantly see the movement of either the right or the left, but not the simultaneous movement of both hands. When asked to look at a needle placed on the table he often failed to detect a pencil placed on one side of it, or if there were two pencils he could see only the one or the other at one time. This affection of visual attention was obvious in many other ways too. While sitting in the ward it was noticeable that the patients usually saw only what their eyes were directed on and they took little interest in what was happening around them, unless their attention was called to it by sounds or other sense impressions. In walking, too, they frequently passed without observing things that would have excited the notice of normal persons.

"This visual inattention was not due to blindness or other defects in the fields of vision, as no defects that could explain it were discovered after careful examination, and images were frequently perceived on portions of the retinæ where similar images passed unnoticed immediately before or after. There was no regularity in perception. This is a condition that results not infrequently from lesions of the parietal lobes, and it may be a unilateral or a bilateral phenomenon. It is commonly found apart from disturbances of visual localization and is entirely independent of this. It plays a part, however, in some of the symptoms we have already dealt with, as if the visual impressions of objects do not attract attention the patient fails to notice landmarks by which he could later find his way, and by which he could construct a geographical picture of his surroundings. In attempting to count objects, too, he is liable to miss out some owing to their images not exciting attention.

Ocular movements. "There were also abnormalities of the eye movements in all my cases, though none of the ocular muscles were paralyzed and the pupillary reflexes were preserved. The most prominent of these symptoms was a disturbance of fixation. When spoken to suddenly the patient first stared blankly in front of him, and then his eyes roamed round the room till they fell, as if by chance, on my face. Similarly it was only after some time and searching that he could bring his eyes directly to an object on one side of his visual axes at which he was asked to look. This difficulty in fixation was a natural consequence of defective spatial localization, for if the position of the object that threw its image on the periphery of the retinæ could not be recognized the eyes could not be moved immediately to it. The fact that most of the patients could turn their eyes promptly to points that they could locate in space, as to parts of their own bodies that were touched or to objects held in their own hands, shows that in these cases this was the explanation of the symptom. But as in a few of my cases and in others that have been recorded the subjects were unable to deviate their eyes directly to points on their own bodies this symptom may be also due to disturbance of the central mechanism of the ocular movements, a disturbance on the effective side which is closely parallel to the perceptual affection on the sensory.

"Accommodation was similarly affected; when an object at which they gazed was approached slowly towards their faces their eyes failed to converge, their pupils did not contract, and as accommodation did not occur the object became blurred or indistinct when nearer than eight inches or so. This was also mainly due to the spatial perceptual disturbances, but as some of the patients could not accommodate on their own fingers accurately an affection of the central mechanism that controls it must be also assumed.

"The blinking reflex was also abolished. These patients never reacted by blinking or withdrawing their heads when anything was suddenly swung towards their faces, or to threatening gestures. In most of the cases this was probably secondary to the loss of spatial perception; some indeed explained that they did not recognize the nearness of the threatening object, but in others the cerebral centers which are concerned in this reflex were probably involved.

"*Stereoscopic vision*, or the power of recognizing thickness and depth in solid objects, was severely affected in only one of my patients. To this man everything appeared flat and bidimensional; he identified familiar things only by associating their areal shape with previously acquired experiences, just as the normal person interprets drawings and pictures as the objects they represent. He described a man who stood in front of him as flat, 'I can only see the front of him, I do not notice that he is thick; I cannot tell the depth in anything.' A box seemed to him a piece of flat cardboard, no matter at what angle he saw it, and when it was placed in his hands he was surprised to discover it was a box. And a glass tumbler looked like a bit of flat glass which changed in shape as it was moved about. When he was placed in front of a flight of steps he saw only a number of straight lines on the floor. Everything seen was flat, nothing had thickness or depth in it; stereoscopic vision was completely abolished and remained so till he passed from under our observation three months after the infliction of the wound.

Position of the anatomical lesions. "In all my eight cases the condition described above was associated with gunshot wounds of the head which involved the posterior and upper parts of both parietal lobes. Post-mortem examinations were obtained in two cases; in both the lateral surfaces were injured in the neighborhood of the angular and supramarginal gyri, while the missiles passed through the mesial surfaces immediately dorsal or posterior to the splenium of the corpus callosum. Craniometric measurements in the remaining cases indicated that in them the same parts of the brain were damaged. As similar symptoms have been observed in cases in which there were vascular lesions limited to the lateral surfaces of the hemispheres in the region of the angular gyri, we can probably attribute the disturbances of visual space perception to destruction of this portion of the parietal association area. It is interesting that certain observations made thirty years ago by Sir E. Sharpey-Schafer on monkeys from which he removed the angular gyri, can now be interpreted as the result of affection of space perception, similar to that with which my patients suffered.

"In attempting to *analyze these symptoms* and interpret their nature and significance we must consider the physiological factors on which spatial localization by sight and tridimensional vision depend.

"The simplest case is localization in a bidimensional plane represented by a hollow sphere, the centre of which would correspond to the pupil. When the eye is focussed on any point on this sphere the concave surface of the retina receives images of all objects that lie on the arc within its field of vision. Then we can recognize the relation in space of any one of these objects to that on which our eyes are directed, and the relation of any other two objects on this arc to one another. This we do by virtue of the local signs of the stimulated retinal points, just as by means of the cutaneous local signs we can localize any contact on the surface of our body.

"But such local signs can serve us only in relative localization to some central point or to our visual axes; they cannot inform us of the absolute position in space of any object with reference to ourselves, as they take no account of the position of our eyes, of our heads, or even of our whole bodies. This additional information we must obtain from proprioceptive impressions from the ocular muscles, from our labyrinth, and from the muscles of our bodies; and when by virtue of these we can become aware of our position in space and the direction in which our eyes are looking, we can, by using the retinal local signs, determine the absolute position in space of the object we see in relation to ourselves. Even in this simple case the association of retinal and various proprioceptive afferents is necessary, and the loss of any of these factors may disturb this function. In the cases described here, the afferents from the labyrinths, and from the ocular and other muscles, were unimpaired, and the symptoms must be attributed either to a disturbance of the local sign functions of the retina, or to the failure of the brain to associate and integrate these with other afferent impressions. Many direct observations showed that the retinal local signs were affected.

"We have to deal with a more complex condition in considering the perception of distance, as there are several other factors concerned in this. Binocular vision undoubtedly plays a part, and the proprioceptive impressions from the intrinsic and extrinsic ocular muscles that are excited by accommodation and convergence contribute to it when the object is near. The estimation of distance is also aided by the apparent size of known objects, by their distinctness and light intensity, and by the parallax that is obtained on movement of either our heads or of the objects. There is no evidence that any of these separate factors were disturbed in my cases. The inability to estimate distance must be ascribed to failure to correlate and associate the various afferent impressions on which perception of the third dimensions may be based, and to assimilate them with past experiences and thereby supply to consciousness the data on which a correct intellectual judgment can be made.

"Loss of stereoscopic vision might be regarded as a natural consequence of inability to appreciate relative distances since, it might be argued, this would make it impossible to discriminate the depths of the different portions of a tridimensional figure. But stereoscopic vision was affected in only one of the eight cases in which the perception of distance was seriously disturbed. The physiological factors on which it depends have been the subject of much discussion; the appreciation of relative distance, difference in light and shade, the parallax and the sense of perspective, all undoubtedly play a part, but it is to the fusion of the non-corresponding images formed in the two eyes and their integration with these other sensory data into a single concept that we mainly owe the appreciation of depth in objects seen. There was no gross disturbance of any of these individual factors in my cases except the appreciation of relative distance, which the intact faculty of stereoscopic vision in the other cases shows was not sufficient. An affection of the sense of perspective may have contributed, but as this faculty is of intellectual origin and acquired by training and experience, we are ultimately forced to regard loss of stereoscopic vision, too, as the result of a failure to combine and associate the different sensations on which the appropriate intellectual judgments can be made, rather than as due to the loss of any of the physiological factors on which it depends."

Visual tract. See **Intracranial organs of vision,** p. 6547, Vol. IX of this *Encyclopedia.*

Visual white. A term applied occasionally to the pigment of the retina in a fully solarized condition.

Visual yellow. A term sometimes applied to the pigment of the retina in a partially solarized condition.

Visuo-auditory. Both visual and auditory; pertaining to sight in association with hearing, or to their centers.

Visuometer. An instrument for measuring the range of vision.

Alfred Smee (*Eye in Health and Disease,* 1854) devised an instrument under this name which he employed for determining the range of accommodation and convergence. This device is constructed upon the principle laid down by Hawkins. A description of Smee's visuometer is given by Donders (*Accommodation and Refraction,* p. 116).

Visuopsychic. Visual and psychic; a term applied to that area of the cerebral cortex concerned in the judgment of visual sensations.

Visuosensory. Pertaining to the perception of visual impressions.

Visus reticulatus. CRIBRIFORM FIELD OF VISION. See p. 3560, Vol. V of this *Encyclopedia.*

Vitali ink. A thick mixture, which when used in writing forms elevated ridges capable of being read by the finger-tips of the blind.

Vitamin. One of a class of substances of unknown composition, existing in minute quantity in natural foods and necessary to normal nutrition and growth, the absence of which from the diet produces deficiency diseases, such as beriberi, scurvy and rachitis.

Vitello, Filius Thuringorum et Polonorum. A 13th century optician, and author of a large volume on optics, which is merely a compilation from the Arab, Alhazen (Ibn al-Haitam).—(T. H. S.)

Vitesse. (F.) Velocity.

Vitiligo. A disease of the skin characterized by the formation of smooth, light-colored patches. It is most frequently seen in youth and adult life. Some cases are probably syphilitic. See John E. Lane (*Journ. Am. Med. Assocn.,* p. 27, July 5, 1919).

A good account of the *ocular aspects* of this disease is furnished in a review (*Oph. Review,* May, 1911) of the papers of Paul Erdmann (*Klin. Monatsbl. f. Augenheilk.,* p. 129, Vol. 49, 1911) and J. Komoto (*Klin. Monatsbl. f. Augenheilk.,* p. 139, 1911). The latter writer describes an instance in a healthy woman aged 33; diminution of vision and photophobia in both eyes set in suddenly, with headache and slight fever. Three weeks later the patient noticed that the eyelashes on both sides had become white. When seen about five months later patches of vitiligo were also present on the backs of the hands and feet. Vision R. and L. 6/12. Fields normal. Anterior parts of the eyes normal. In the vitreous there was some fine dusty opacity. The nerve was slightly pale. The choroid showed a very notable diminution of pigment in its whole extent, the fundus being almost albinotic, but with a generalized scattering of fine pigment, and with larger round and linear areas here and there, especially in the macula and round the papilla. Photophobia was still present.

In Erdmann's case, although there were points of similarity, inflammatory symptoms were more prominent. The disease began with night-blindness, and six months later a chronic choroido-retinitis with vitreous opacity was added. The fundus round the papilla was semi-albinotic. Vitiligo began about the same time as the eye symptoms, ran a course roughly parallel with them, and improved with their subsidence. No other cause of the ocular symptoms could be found, and the Wassermann reaction was negative.

Is the evidence in these cases sufficient to exclude coincidence? At first sight it is difficult to believe that a very chronic, apparently non-inflammatory disease like vitiligo could have any intimate causal relationship with definite, and even moderately acute, signs of inflammation in the eye. On the other hand the contemporaneous depigmentation of the skin and choroid in Komoto's case is certainly remarkable; the association of bleaching of the eyelashes with sympathetic ophthalmitis is mentioned by Komoto as an illustrative analogy, and he also quotes a case in which the hair of the forehead over a sympathizing eye became white; it is said also, but the observation seems to be doubtful, that slight inflammatory changes have been found in the skin in vitiligo. On the whole therefore it would seem that a specific relationship, most probably a common dependence on some nervous influence, is not inconsiderately to be excluded.

A more doubtful case of Gilbert's is quoted, in which vitiligo was associated with double optic neuritis and a nodular form of iritis. The patient had a carcinoma of the axilla. Gilbert's suggestion that the iritis and optic neuritis were "herpetic" in origin had rather a fanciful sound, but perhaps emphasizes the same idea, that the ocular conditions are a tropho-neurosis.

K. Steindorff (*Klin. Monatsbl. f. Augenheilk.*, 53, p. 188) describes a case of *vitiligo of the lids* and poliosis after a contusion. A woman, aged 25, sustained at the age of about 4 years, a contusion on the left side of the forehead, without hemorrhage. After some time the hair at the vertex in an area of the size of the tip of a finger, and a vertical strip of the skin of the forehead, 1 cm. wide, became white. Then the corresponding portions of the eyebrow, skin of the upper lid, and the lashes of both lids turned white. Soon the hair regained its former color and after a few years the skin of the forehead became normal, but the eyebrow, skin of the lids, and lashes, remained light. Microscopically the cortex of the epilated lashes contained not a trace of pigment. The medullary substance appeared as a dark strip composed of very fine dots, which disappeared in hot water, showing that these were not pigment granules, but air.

Vitiligo and canities of the lashes after blunt injury, as in this case, has never been observed before, and there is only one publication on traumatic vitiligo by Chajes. The writer assumes a trophoneurotic affection, due to disturbances of blood and lymph circulation caused by the lesion of the trophic nerves of the forehead. This is supported by a case of Cassirer who saw in a nervous woman, aged 20, of a nervous family, after a strain combined with fright, left-sided ptosis, miosis and sudden canities of the medial portion of the eyebrows, lashes and the thin and scanty hairs of a mustache. The oculopupillary symptoms disappeared, but the canities remained.

Demaria (*Arch. dé Oft. Hispan.-Am.*, July, 1917) observed two cases of severe, bilateral uveitis in two patients affected with vitiligo. In a man aged 18, the coincidence of the ocular condition and the vitiligo was so marked, that it would have been easy to correlate both conditions. In a woman aged 43 years, the uveal inflammation started six years after the beginning of the vitiligo and was very severe. However a general examination did not show other pathologic conditions to which the ocular condition could be referred. In the first case a tuberculin injection gave a strong positive general and local reaction, and in the second case the Wassermann was positive.

Demaria thinks that the vitiligo had nothing to do with the eye trouble, but was a mere coincidence; and that the tuberculin and Wassermann tests show the true nature of the disease. He even doubts if in the cases reported by Gilbert in 1901, and Erdmann and Komoto in 1911, there was observed a true relationship between the vitiligo and the optic neuritis and uveitis and choroiditis, or if they were of other origin; because, except in the case of Erdmann, diagnostic tuberculin injections were not made. Additional clinical observations are necessary to settle this question. See, also, **Leukoderma.**

Vitiligoidea. See **Xanthelasma.**

Vitón's tuberculin test and treatment. The "Argentine method" of giving extremely minute doses of tuberculin has been repeatedly mentioned. Vitón (*Semana Médica*, April 22, 1920; abst. *J. A. M. A.*, Sept. 4, 1920) insists that in applying the tuberculin test it is as important to avoid an appreciable local reaction as a general febrile reaction, as both do serious damage. The optimal dose has to be determined tentatively for each individual. The diagnostic reaction is when there is a decided improvement in the focus, not an aggravation. This decided improvement in the focus and in the general condition is maintained by continuing the optimal dose until its effect is exhausted, and then increasing the dose a little. He argues that as statistics show that nearly every one of us is tuberculous, this infection must be a factor in many affections in which hitherto tuberculosis has not been incriminated. By his method of tuberculin treatment in extremely minute doses, this factor is eliminated more or less completely, and the system is then able to throw off the whole affection.

Dilutions of the tuberculin from 1:100,000,000 to the figure with fifteen zeros are what he uses in the subacute and chronic rheumatism of Poncet, neuralgias, dorsal myalgias, disordered heart action, arrhythmia and functional disturbances of various kinds without much impairment of the general health, and in all cases of mild impregnation with tuberculous toxins with little if any derangement of the metabolism. This is the "tolerant group" of patients. The "sensitive group" includes external glandular processes, paratuberculosis, dyspepsia, endocrine derangement (exophthalmic goiter, hyperthyroidism, ovarian disturbances, etc.), diabetes, neuritis, and lesions of the eyes. In this group he uses dilutions of the tuberculin with from fifteen to twenty zeros. His third group embraces asthma, tuberculous nephritis, mild tuberculous toxemia and incipient apical disease. This group is treated with dilutions of from twenty-one to twenty-six zeros. The fourth group, the "hypersensitive," includes frankly febrile lesions and softening and cavity formation in the lungs. In this group he uses the tuberculin diluted to twenty-seven zeros. With these minute doses of tuberculin the organism is helped, not damaged at first before help is applied, as is the case with ordinary tuberculin treatment. He advises a tentative course of the kind in every pathologic condition which, contrary to expectation, shows no tendency to recovery under persevering classical treatment. Also in every slow chronic syndrome of whatever nature, and every pathologic condition for which no definite cause can be discovered. He has had great success, he relates, in tuberculous affections of the eyes rebellious to all other measures, including tuberculin by the ordinary excessive dosage. It does not conflict with other treatment, and systematic prophylaxis by this means in jails, schools and factories might modify the predisposition to phthisis and thus ward it off.

Vitreocapsulitis. (Obs.) Inflammation of the capsule inclosing the vitreous; hyalitis.

Vitreous. VITREOUS HUMOR. VITREOUS BODY. CORPUS VITREUM. VITREUM. The *anatomy* and *histology* of the vitreous are described on p. 377, Vol. I and on p. 5964, Vol. IX of this *Encyclopedia.*

It may be further remarked that the important question of *vitreous drainage* into the lymph channels of the optic nerve is discussed by Behr (Graefe's *Archiv. f. Ophthalm.,* Vol. 83, No. 3, 1912). Into each of six patients, the vitreous of an eye which was doomed to enucleation was injected at an interval of from ten minutes to one hour before operation with a solution of methylene-blue, or in one case with an emulsion of India-ink. To prevent acute rise of tension, an equal amount of fluid was withdrawn from the anterior chamber. There was no leakage from the punctures. Immediately after enucleation the optic nerve was cut from the globe at the lamina cribrosa, and both cut surfaces examined for coloring matter under the binocular microscope. The nerve was further examined in frozen sections. In no instance did the nerve or its sheaths show any trace of staining. Injection of the optic nerves of cadavers with methylene-blue, on the other hand, failed to produce any staining of the vitreous, although the staining fluid penetrated between the nerve-fibers into the disk and the surrounding retina, as well as through the perivascular spaces of the central vein and its branches far beyond the equator of the eyeball. Behr therefore concludes that in man there is no communication between the vitreous and the optic nerve. Arguing further that, if such a drainage system existed, the stasis of choked disk should be expected to increase intra-ocular tension, he measured with the tonometer the tension of a number of cases of papillitis. In each instance the reading was below 18 mm. of Hg.

L. Koeppe (*Archiv. f. Ophthalm.,* p. 199, Vol. 97, 1919) with the Nernst-Gullstrand light and corneal microscope does not find the presence of a hyaline membrane in the posterior half of the vitreous, but there appears to be merely a thickening of the posterior marginal layer similar to that in the anterior portion of the vitreous.

Vitreous, Artificial. A term applied to any substitute for the vitreous, either in the treatment of intraocular conditions (usually in the form of intravitreous injection) or, after evisceration, the substitution of a glass ball, etc., to form a support for a prothesis. See p. 4429, Vol. VI of this *Encyclopedia;* as well as **Vitreous replacement.**

Vitreous, Bisection of the. The name given by R. Deutschmann (*Beiträge zur Augenheilk.,* 20, 1895) to an operation for retinal detachment. See **Retina, Detachment of the.**

Vitreous cataract. An obsolete term formerly used to describe the result of a chronic inflammatory condition of the vitreous with dense opacities involving the posterior capsule and sometimes the posterior layers of the lens.

Vitreous chamber. The cavity posterior to the lens and suspensory ligament and occupied by the vitreous body.

Vitreous, Cholesterin in the. See **Cholesterin,** p. 2117, Vol. III, and **Synchisis scintillans,** in this *Encyclopedia.*

Vitreous, Coloboma of the. This is a rare congenital anomaly which appears as a cleft in the under part of the vitreous body, extending in the most marked instances from the optic papilla to the ciliary region, while in lighter grades it occupies only the anterior or posterior part of the vitreous.—(J. M. B.) See, also, p. 2910, Vol. IV of this *Encyclopedia.*

Vitreous, Cysticercus of the. See **Vitreous, Parasites of the.**

Vitreous detachment. See **Detachment, Vitreous,** p. 3858, Vol. V; also see this sub-head under **Retina, Detachment of the,** herein.

Vitreous, Development of the. This subject has already been treated on p. 3893, Vol. V of this *Encyclopedia.* Here it may be said that the most extensive and recent investigations of the subject have been made by Mawas and Magitot. See *Ophthal. Year-Books* for 1912, 1913 and 1914. In their earliest studies these investigators concluded that there is a vitreous body *exclusively of retinal origin,* developed before it is penetrated by blood-vessels. With the entrance of the blood-vessels into the vitreous, at about the eighth week, and with the formation of the crystalline lens, mesoblastic elements penetrate this original vitreous, and a temporary vitreous body of mixed ectodermic and mesodermic origin is formed. Subsequently, with the hyaloid vessels, this temporary vitreous disappears; and is replaced by the permanent vitreous, which is of retinal origin and largely a development of the ciliary portion of the retina. The vitreous developing in this way, they believe, there is no true hyaloid membrane; but that the external limiting membrane is composed of the bases of neuroglia cells derived from the retina. Such a scheme of development marks the eye as more clearly an off-shoot of the central nervous system. The retinal origin of the vitreous also explains the intimate association of vitreous and retinal opacity and hemorrhage.

They also hold that the vitreous is of ectodermal origin, and is divided in its development into three stages, the primordial, transitory and final. The first is a product of the marginal zone of the embryonal retina, hence of the inner layer of the secondary optic vesicle. The hyaloid system of vessels appears at the beginning of the fourth week and almost fills the interior of the eye, a number of connective-tissue cells are forced in with it and form the anterior mesoderm plate, having a vessel-forming part solely. The transitory vitreous is marked by a mantle of neuroglia which appears at the end of the eighth week, envelops the hyaloid vessels, and, like the latter has only a transient existence. Toward the end of the tenth week, at the time of the greatest development of the transitory vitreous, a very lively retinal development sets in, Mueller's cells proliferate and send out a dense, delicate fibrillary network into the interior of the eye. From the third month the central canal is formed from the transitory vitreous which steadily retrogresses. With the vessels disappears also the neuroglia tissue, traces of which can often be seen in front of the papilla. The entire optic retina takes part in the formation of the final vitreous fibers, even the ciliary portion developing a lively activity. The latter creates the greater part of the anterior vitreous fibers, as well as the fibers of the zonula, the first rudiments of which can be seen in the third fetal month. The final vitreous also comes from the development and further growth of the primary vitreous, which was transiently hidden by the development of the transitory vitreous. Of the ciliary retina only the layer of the non-pigmented cells takes part in the formation of the zonula, the latter has therefore an exoplastic genesis. Toward the end of the third month the transitory vitreous is gradually compressed and absorbed by the final part; parts of it are still present in the center of the eye at the end of the seventh month. There is at no time an empty space between the two formations; a true central canal exists neither at this time nor later. It would appear from this mode of development that in man neither a hyaloid membrane, nor an internal limiting membrane of the retina exists, and that because of its direct retinal origin the vitreous as well as the retina is to be looked upon as a part of the central nervous system.

Franz accepts the views of Mawas and Magitot of the *ectodermal origin of the vitreous.* His theory is that it is to be regarded embryologically as a greatly developed and structurally modified basal membrane derived from the retinal cells. If so, it necessarily follows that when the fetal cleft remains open, a cleft of the vitreous must also result. He claims that this can be demonstrated in teleostean fishes in which the cleft remained open permanently to give passage to the falciform process. Again, if his theory be correct, it follows after the cleft has closed, the original cavity of the secondary optic vesicle must be represented not by the vitreous cavity, but by the canal of Stilling. It is along this canal that the pecten of the bird's eye runs, but the author admits that no channel is traceable beyond its free end.

Franz believes that the mammalian canal of Stilling, the pecten of the bird, and the processus falciformis of the fish are not, as is often stated, homologous. The canal of Stilling is a remnant of the cavity of the secondary optic vesicle, the pecten of a neuroglial proliferation into this cavity, and the processus falciformis the turned-in edges of a persisting fetal cleft, with the mesoderm between them. As regards the pecten, it might be suggested that since it contains numerous vessels, the mesoderm as well as the neuroglia must share in its formation.

Calderaro (*Oph. Year-Book,* p. 228, 1912) has carefully studied the *embryology of the axial vitreous,* including the hyaloid artery, the papillary sheath, and the hyaloid canal. The artery can be recognized as a branching trunk extending forwards towards the lens in the embryo of the twelfth week. Its distal portion bends downward and towards the nasal side. Regressive changes begin in the fifth month. In the sixth month the circulation ceases and the replacing cord of the seventh month disappears in the eighth or ninth month. The prepapillary mass, which Magitot and Mawas compare to a muff surrounding the artery, becomes transparent as the vessel disappears. The hyaloid canal was recognizable in the fifteenth week, passing forward and spreading like a funnel to the back of the lens. Its section is oval with the long axis vertical. In the fourth month it begins to narrow and to shrink back towards the disk.

Vitreous, Entozoa in. See **Vitreous, Parasites of the.**

Vitreous, Examination of the. The lens being clear, the anterior part of the vitreous can be examined by the oblique method. Practically the ophthalmoscope is necessary in the examination of this humor.

With a dilated pupil gross changes can be seen by using a concave retinoscopy mirror of twenty-five centimetres' focus. If the vitreous is opaque in spots, it will be necessary to determine whether the opacities are floating or fixed. The patient is told to move the eye quickly up, then down, and he is then to stop suddenly at the middle line. This will cause floating bodies to move. This maneuver shows large opacities plainly, but small, dust-like spots can best be seen by the direct method of ophthalmoscopy. Fixed opacities must be studied by the same method. The localization of foreign bodies in the eye by the use of the x-rays has come to be of great value.—(J. M. B.) See, also, **Examination of the eye.**

Vitreous, Fluid. SYNCHISIS CORPORIS VITREI. This condition arises as one of the results of choroiditis or retinitis, and is found in high myopia by reason of the fact that in these conditions the nutrition of the vitreous is disturbed. Under these circumstances the vitreous body becomes a thin fluid of a straw color. In cataract extractions it is sometimes observed that considerable watery fluid, in excess of the amount of aqueous, flows out of the wound. In such patients the anterior part of the vitreous has become thin. With diminished consistency there may be shrinkage of the vitreous. The anterior chamber may be increased in depth from a backward movement of the lens, and detachment of the retina may be present. According to Griffith, in cases of fluidity of the vitreous the ocular tension is more often increased than diminished. Tremulousness of the iris is often present in this disease. The condition does not admit of successful treatment. (J. M. B.) See, also, **Synchisis corporis vitrei.**

Vitreous, Foreign bodies in the. This subject has been freely discussed under numerous appropriate headings in this work. See **Military surgery of the eye,** and the **War** captions, also and especially, p. 5268, Vol. VII and the references thereunder. A few additional observations are made here.

Copper fragments in the vitreous. See **Copper in the eye,** p. 3309, Vol. V of this *Encyclopedia.* Additional references are here given. T. von Speyr (*Klin. Monatsbl. f. Augenheilk.,* 53, p. 195, 1916) reports the *removal of a piece of copper from the vitreous.* The left eye of a man, aged 21, was injured in the forenoon by explosion of a cartridge capsule. V=0.5 The cornea showed a fine linear injury, the iris an irregular hole, 1 mm. square, the lens a corresponding opacity, and the vitreous a light-yellow, metallic lustre. In the evening, under illumination of a Nernst lamp, a small pair of forceps with excavated ends were, under local anesthesia, twice introduced through a meridional section of the sclera, 7 mm. long, between the lateral and inferior rectus, after previous dissection of the conjunctiva, but did not grasp the foreign body. After the second attempt the copper fragment appeared in the wound evidently following the traction of the vitreous, caused by the withdrawal of the forceps. The writer emphasizes this point, as perhaps the current of fluid may in similar cases suffice for extraction of a foreign body, so that it will not be absolutely necessary to seize it, as repeated attempts entail considerable damage to the vitreous tissue.

The wound was closed with scleral and conjunctival sutures. Seven weeks later the cataract was extracted. There were no opacities of the vitreous. Steindorff advises extraction of the foreign body as early as possible, and not to wait for formation of exudates.

Reese, also, who observed cataract from injury to the lens by a piece of copper from an explosion, extracted the fragment, which was seen floating in the vitreous. The patient was put in the knee-chest position, when the foreign body fell into the anterior chamber, from which it was removed with forceps.

Inasmuch as *copper* remaining in the interior of the eye is almost certain to destroy the sight, any method of extracting this and other non-magnetic metallic bodies would be of service. To accomplish this after very exact localization, Weve has had constructed a steel, copper-plated forceps, except at the point and inner surface of the branches, such that a noise is elicited when the instrument comes in contact with the copper. The mechanism can be understood only by those who are familiar with the theory and construction of the telephone, on the principle of which the method is based. The inventor appears to have had no actual experience with his forceps other than experiments in salt solutions corresponding in content with that of the vitreous. In such experiments very minute pieces of copper were distinctly, though faintly, ascertainable.

In the removal of shot Kunz proceeds as follows: In all cases of suspected foreign body the region is first transillumined and two skiagrams taken in two positions at right angles to one another. The horizontal plane in which the foreign body is located is then marked with a colored pencil on the skin. This plane, which may be termed the plane of the foreign body, is of special importance: errors above or below it are excluded; the line previously marked (after treating the field of operation with iodin) is painted with a 50 per cent. silver solution which causes it to show plainly in white. The incision is now made at right angles to the plane of the foreign body, and so as to bisect the same. This constitutes coarse orientation.

In the case of small foreign bodies the writer proceeds, if necessary, to a method for more exact orientation. A thick piece of copper wire is sutured into the bottom of the wound and two additional skiagrams are taken so that the projectile can always be easily found. For the skiagram not the ordinary plates but bromicized silver paper is employed: the latter permits the operation to be continued with but little loss of time. For the determination of the plane of the foreign body it is indispensable that the Roentgen tube be exactly centered in order that the central ray may be perfectly horizontal. To obtain accurate results, the operator must always have a clear idea, during the Roentgenological part of the work, what position the field of operation is to take during the operation, so that the Roentgen ray determinations may be made while maintaining the same position.

Kaspar Pischel (*Jour. Amer. Med. Ass'n.*, Oct. 9, p. 1232, 1915) reports the *removal of birdshot from the vitreous through the pupil.*

The patient was a boy, aged 12. While hunting, a birdshot No. 9, fired from his companion's gun, at a distance of about 50 yards, entered his left eye. The sight was immediately gone. The local physician gave him 10 c.c. streptococcus serum. The writer found: Right eye: Sight 5/4, fundus normal. Left eye: One mm. up inward from center of cornea a triangular gray flap, lens cataractous, swollen; iris showed a tear in pupillary margin corresponding to the corneal wound. Fundus was not visible. Pupil dilated irregularly with several posterior synechias after atropine. The Roentgenogram showed a shot in the vitreous downward-inward from the center.

In consultation, the opinion was divided between removal of the eyeball and preserving it.

Patient was sent home to the country. Two months later the pupil in upper part was clear. With transilluminator; gray, floating membranes could be seen in the vitreous.

Nearly three months after the accident the patient returned again, and gave the following history: The day before, while wrestling with a boy he fell on him and bumped his head against the other boy's. He immediately felt a sharp pain in the left eye, lasting several hours.

To Pischel's astonishment the shot lay now in the lowest part of the anterior chamber, whence it was removed under a general anesthetic. Apparently the fall forward and the striking of the head had caused the shot to pass through the pupil into the anterior chamber. The eye quieted down rapidly.

This accidental occurrence shows us a way for the therapy in such cases, and the writer suggests removing the cataract as soon as possible and then trying to bring the shot into the anterior chamber through the pupil by methodical stooping exercises and even judicious bumping of the forehead while lying flat on the abdomen.

Vitreous, Fungus growths of the. Artificial infections of the vitreous by various fungi are on record. Weeks (*Text-Book,* p. 606) remarks that cultivations of the *aspergillus fumigatus* have been found in the vitreous (Römer, *Klin. Monatsbl. f. Augenheilk.*, p. 331, April, 1902) as a result of a penetrating wound of the eye. Some pain was experienced and hypopyon was present on the thirteenth day. Examination after enucleation on the fourteenth day disclosed the presence of the fungus in the vitreous. Leber, Noble, and others have reported similar cases.

Vitreous hemorrhage. In addition to the matter on p. 5802, Vol. VIII of this *Encyclopedia,* a few words may be said about the *treatment of the various types* of intravitreous bleeding.

In *subhyaloid hemorrhage* (q. v.), first described by Hotz in 1893, the patient's general condition should be investigated and any systemic disease appropriately treated. Complete rest of the eye under atropine, the regulation of the dietary and mode of life and the use of iodide of potassium in large and increasing doses with pilocarpine sweats (q. v.) will be found useful. As the prognosis is favorable, proper treatment will generally bring about a cure.

Spontaneous vitreous hemorrhage. Apart from vitreous bleedings due to the rupture of a diseased vessel or as a consequence of hemorrhagic choroiditis, high degrees of myopia, syphilis and disease of the ciliary body (in which cases the conduct of the bleeding merges into that of the treatment of the underlying causes), not a few instances of spontaneous hemorrhage occur.

The *treatment* of this last condition is practically the same as that of cases of opacity of the vitreous humor. After a purgative followed by a saline laxative, hypodermic doses of pilocarpine (q. v.) should be given with sweat baths if the patient can stand this vigorous treatment. Iodide of potassium with mercurials can be used later with advantage, or, if they are not too powerful, can be given in conjunction with this treatment.

The *treatment of recurrent or relapsing vitreous hemorrhage* is discussed on p. 5803, Vol. VIII of this *Encyclopedia.*

Under the title *massive spontaneous hemorrhage* Leighton Appleman (*Am. Journ. of Ophthalm.*, Jan., 1918) has described three cases of recurrent hemorrhage in persons under 40 years of age.

Treatment of traumatic vitreous hemorrhage. Ormond (*Ophthalmoscope,* p. 461, Sept., 1916) has contributed an excellent discussion on the subject of the treament of large traumatic vitreous hemorrhages, the patients having come under observation during the late war. He dwells on the possibility of absorption by either mechanical or chemical means, also the possibility of delaying coagulation. The use of massage; ionization; subconjunctival injections; removal of some of the fluid and its substitution by normal saline; fibrolysin; dionin; potassium iodid and radium is each in turn discussed. He believes some of his patients have been benefited by treatment. He attributes the influence of massage, ionization, subconjunctival injections and dionin to mechanical causes. The removal of fluid and its replacement by normal saline is of doubtful benefit, and the same can be said of radium. Fibrolysin may influence the condition by the production of a leukocytosis. As to the iodid he states that its supposed absorbent properties are so ancient that we must admit that it is probably of value, although we are not in a position to say exactly how it acts. At any rate it is the only drug he knows of that benefits absorption.

In reviewing Ormond's paper Darier states that for traumatic vitreous hemorrhages the most efficacious treatment is local cupping or leeching, and in the more serious cases general bleeding. He has found auto-serotherapy useful. He believes the administration of a vasoconstrictor to be most useful in cases of recurrent hemorrhage of adolescence. Emetin and gelatinous serum are suggested for the post-operative type, while in the retinal hemorrhags of pregnancy he would use local bleeding.

Vitreous, Hernia of the. See **Hernia of the vitreous,** p. 5879, Vol. VIII of this *Encyclopedia.*

Vitreous, Hyaloid membrane of the. See **Vitreous.**

Vitreous, Hydatid cyst of the. See **Vitreous, Parasites of the.**

Vitreous, Infection of the. Wounds of the vitreous carrying infection act primarily on the surface of the membranes covering the vitreous body—the retina and ciliary body. Exudates extend from the ciliary body and processes into the fossa patellaris, forming a tough exudation membrane in which a localized vitreous abscess may develop. From the retina the exudate covers its inner surface and it soon becomes detached and wrinkled, beginning near the outer margin of the optic nerve. The infiltration of the retina and papilla and detachment of the retina is likewise speedily effected by the toxins of the infection, which combination accounts for the rapid extinction of the light perception.

Hence the amount of light perception is the distinguishing mark for enucleation in these cases; the eye should be removed as soon as the perception is lost. Sometimes when such enucleated eyes are opened the retina and optic nerve do not display the grave changes that we expect to find, and even under the microscope they prove to be almost normal. This agrees with the clinical fact that in many cases in which enucleation is not performed the light perception, which has been almost lost, is restored. In others, however, the grave purulent infiltrations above described exist. In the lighter cases the organization of exudate in the vitreous occurs, which ultimately shrinks, causing atrophy of the eyeball. A marked example of this is the effect of copper particles on the vitreous. In these severe cases the exudate consists wholly of pus and is incapable of organization, causing different degrees of inflammation, according as the suppuration is circumscribed, when it is possible to make a diagnosis of abscess of the vitreous. Here where the anterior part of the eye remains transparent we may see a yellow reflex behind the lens, the pus *in situ.* This is later transformed into a membrane which shrinks and causes detachment of the retina with atrophia bulbi.

If the process be very virulent the case goes on to panophthalmitis, perforation of the eyeball, and phthisis bulbi.

Aseptic suppuration may occur from chemical irritation, especially in the case of copper particles, and cause a localized abscess of the vitreous, most instances of which end in atrophia bulbi, but a few in recovery.—(H. V. W.) See, also, **Vitreous, Inflammation of the.**

Vitreous, Inflammation of the. See the **Hyalitis** captions in this *Encyclopedia.* In addition Benson has described two rare types of the disease, as follows: (1) *asteroid hyalitis*, characterized by small, fixed, highly refractile, globular masses in the vitreous that are cream-colored by the oblique illumination. In the case described by the writer (*Trans. Oph. Soc. Un. Kgdom.*, p. 10, Vol. 14) they were unchanged for the nine months the case was under observation.

(2) *Hyalitis punctata.* As stated by Weeks (*Text-Book*, p. 600), Benson (*Oph. Review*, p. 304, Vol. VII), designates an appearance similar to keratitis punctata which he observed as situated just back of the crystalline lens. The patient had syphilis and was suffering from keratitis punctata and a mild iritis. Weeks has seen a similar condition, the spots apparently occurring on the capsule of the lens in the patellar fossa, in a patient suffering from a mild cyclitis.

Commenting on Straub's theory (see **Hyalitis,** p. 6070, Vol. 14 of this *Encyclopedia*), Herbert Parsons (*Oph. Review*, p. 378, Dec., 1911) said he understood Straub's contention to be that leucocytes were carried forward in the lymph stream, and his explanation of the formation of the dots was a very ingenious one. But the speaker criticized the use of the term "hyalitis" and "descemetitis," as he regarded their use as backward steps in pathology. The tissue under discussion was non-vascular and apparently passive, whereas inflammation was pre-eminently an active process. Parsons had hypothecated that where there were dust-like opacities in the vitreous associated perhaps with choroidal change, there was really a low grade of cyclitis going on to account for the presence of those opacities, and that they were not due to any inflammation present in the vitreous, *per se.* Supporting that view was the fact that in cases of choroidal inflammation there was no transference of leucocytes or organisms directly from the choroid into the vitreous until the membrane was burst through.

For further discussion of *dust-like vitreous opacities*, see *Trans. Oph. Soc. Un. Kgdom.*, p. 60, 1912.

Vitreous Injuries of the. See, also, **Vitreous, Loss of the; Vitreous hemorrhage** under treatment of *traumatic vitreous hemorrhage*, and various other related **Vitreous** headings.

Wounds of the vitreous are followed by more or less dense opacities which interfere with vision, according to their location in respect to the visual axis, with shrinking of the vitreous, if with considerable resultant detachment of the retina and atrophia bulbi.

This condition occurs from the contraction of exudates which come from inflammation of the ciliary body, the choroid and retina. Contraction of the vitreous body and resultant retinal detachment may also occur after wounds of the vitreous without the formation of exudates.

Infection of the vitreous by pus germs leads to loss of the eye by panophthalmitis.

The prognosis of wounds of the vitreous depends upon the possibility of infection and the contraction of exudates. As a rule wounds of the anterior portion of the vitreous, as in discission of secondary membranes in the pupil, heal without leaving perceptible traces. Loss of over 20 per cent. of the vitreous leads to retinal detachment and atrophia bulbi.

Foreign bodies in the vitreous substance. The following discussion is confined as much as possible to foreign bodies remaining in the vitreous itself.

Particles of iron, steel, copper, stone, glass, and wood are most common, especially the metals. Shot, powder, and sand are less often seen. The great expansion of the iron and steel industries has given rise to this form of accident which, previous to our era, was much of a curiosity. With the exception of such countries as Switzerland and France, where women work with hoes on stony land, the occurrence of foreign bodies within the eye is practically limited to men, and mostly to those in the iron and steel trades, copper and brass workers, stone-cutters, etc. Powder grains occur from explosions of fireworks, gunpowder, and from blasting, in the latter sand grains usually accompany.

Rare objects such as portions of whip lashes, bone, wax, cilia, etc., have been reported.

The luxated lens must be considered a foreign body, as well as the occurrence of cysticercus in the vitreous.

Foreign bodies enter the vitreous (1) either through the cornea and pupil, through the central portion of the lens; (2) through the cornea, iris and lens, in which cases traumatic cataract is also produced; (3) through the cornea, iris and zonule, in which the body of the lens is not impaired; (4) through the sclera, with or without injury to the ciliary body.

As a rule a foreign body entering the eye with sufficient force to penetrate to the vitreous reaches the opposite inner wall and rebounds to again pass into the vitreous and remains, generally gradually sinking to the bottom of the eye. If coming with a little more force the foreign body may rebound sufficiently to again pass into the retina, ciliary body or lens and if with enough force it may pass entirely through the posterior walls of the globe into the orbit, as is common in wounds from bird shot.

Splinters of metal usually richochet. In 19 enucleated eyeballs the foreign body had reached the opposite wall in all cases, in 14 had rebounded, in 4 stuck in the posterior wall, and in 1 had passed through into the orbit.

Foreign bodies remain in the position left after the accident until moved by some mechanical force such as movement of the head and body, which gradually causes them to fall to the lower part of the vitreous, as the vitreous usually becomes fluid. Detachment of the retina and shrinking of the vitreous likewise dislodges them. The chemical irritation set up by foreign bodies aids in their wandering and sometimes in their complete extrusion.

Vitreous foreign body symptoms. If the foreign body pass through the central part of the cornea, the wounds or their cicatrices will be seen if the media be sufficiently clear; one each in the cornea, anterior and posterior capsule of the lens, in a line with one another and with the wound canal or opacity in the lens showing between the lenticular capsule wounds of entrance and exit. If the splinter turn in its course it may deviate from this straight line after entering the eye, especially after leaving the lens for the vitreous, and take a parabolic course, or turn at an angle. If passing completely through the eye, the posterior perforation shows if not covered by a blood clot; upon resorption of the blood the tear in the retina and sclera will be seen by the ophthalmoscope. If the foreign body pass through the iris the opening will be seen therein, as iris wounds never close. If through the sclera the site will be marked by a blood clot, which at first fills in the wound. It may be that the shot or splinter first passed through the lid, most commonly the lower, in such cases the wound canal may be followed by probing.

In many cases it is impossible to determine the location of the foreign body by inspection, focal or transillumination, or by the ophthalmoscope, on account of opacities of the media, but in those where such examination is possible the foreign body may be seen by the ophthalmoscope, if not too near the ciliary region, and its location estimated by its behavior on parallactic examination. In a few cases the portion of the posterior wall from which it rebounded may be seen as a bloody spot on the retina, and its course through the vitreous be visible as a diffuse linear opacity. In some cases air bubbles are to be seen in the vitreous along the course of the foreign body. These show as little, sharply defined round spots with light centers and dark rims, and in most cases a line of blood pigment or blood will show the direction of its passage.

As there are no sensory nerves in the vitreous the pain and irritation, if any, is referred to the external wound or to secondary inflammation of the iris and ciliary body. The sight is affected from the injury to the lens, or if this remains clear, by the bleeding or opacities in the vitreous. If the media remain clear the foreign body may be entoptically seen by the patient.

As a rule eyes having a foreign body in the vitreous go on to plastic irido-cyclitis, with loss of vision in the injured eye and possible sympathetic ophthalmitis in the fellow. In but few cases does a foreign body become encapsulated. Some, however, have been reported remaining in the vitreous for many years. Intruders carrying virulent pus germs cause acute suppuration and panophthalmitis; other less active germs cause irido-cyclitis and sympathetic inflammation. Those that cause irritation either through the gravity of the trauma, their location or their chemical nature, produce shrinking of the eyeball, iridocyclitis, and sympathetic irritation.

Iron in the vitreous. Infected iron particles do not as a rule cause infection of the wound of entrance, but such occurs from the conjunctiva, lids or from extraneous infection, but they begin to form abscess in the vitreous in 12 to 48 hours, which spreads, infiltrating the posterior portion of the eye and then the uvea. If the infection be of a mild type the abscess does not form but the tissues so strongly react that the foreign body becomes encapsulated. A perfectly clean splinter of iron or steel never causes encapsulation. While encapsulated foreign bodies may remain in the vitreous for a very long time they sooner or later cause chemical irritation and inflammation of the retina and vitreous so that the eye is ruined thereby.

The vitreous becomes opaque, thickened, and then shrinks; the retina then detaches; in some cases a disease of the pigment epithelium of the macula with irregular spotting pigmentation. Most cases of reactionless particles of iron in the posterior portion of the eye, with retention of good vision, were encapsulated in the retina.

Larger pieces of iron, which cause loss of vision, may heal in the eye and remain for years. As a rule, however, such large pieces immediately cause severe symptoms of inflammation so that they must be removed at once, together with the eye.

Many cases of sympathetic inflammation are reported in the literature produced by the retention of a foreign body.

Iron splinters may be spontaneously extruded from the vitreous, though more seldom than in the case of copper.

Copper in the vitreous. Particles of copper, even if aseptic, in the vitreous, nearly always cause severe inflammation from chemical irritation, producing an aseptic purulent exudate and later thickening and shrinking of the vitreous with total detachment of the retina and irido-cyclitis, closing the chapter with atrophy of the globe after months of painful inflammation. If septic, panophthalmitis, perforation, and phthisis bulbi occur.

The encapsulation of copper in the vitreous with retention of good vision is not often observed. Cases have been reported where, while the sight had been lost from plastic inflammation the eye remained quiet. It is impossible to estimate how long such encapsulated foreign bodies may remain innocuous without producing renewed inflammation and sympathetic ophthalmitis in the other eye.

A number of cases of spontaneous extrusion of a piece of copper from the vitreous have been reported, this occurring from copper far more often than in the case of iron and other foreign bodies. This occurrence is due to late development of infection, the copper salts forming from contact with the fluids of the eye, setting up an inflammation and letting loose the germs which had been locked up by encapsulation; the copper salt acting in the uveal and scleral tissues and softening them so that the foreign body extrudes at this point.

Experiments show that copper need not carry sepsis in order to produce pus, and that extrusion of the aseptic foreign body from the eye is not necessarily a septic process as in other parts of the body.

Lead and glass in the vitreous. While glass splinters are, as a rule, aseptic and become encapsulated without causing much irritation, and may remain for many years in the eye, yet chemical changes arise from contact with the vitreous causing shrinking of the vitreous and degeneration and detachment of the retina.

As a rule traumatic irido-cyclitis follows with retinal detachment, atrophy of the globe or infection of the wound by pus germs, and panophthalmitis. The wound of entrance by glass is, as in the case of stone and wood, larger, more contused and lacerated than from small grains of iron and copper.

It is different with shot and powder grains, for these may remain in the eye for a long time, becoming encapsulated and not giving rise to inflammation.

Stone, wood, coal and other particles become encapsulated but, like glass, lead later to inflammation and irido-cyclitis. Occasionally such may remain for a long time.

The spontaneous extrusion of stone, wood, coal and glass is uncommon; they may remain for a score of years or more, though the eye be ruined by the resulting irido-cyclitis. Only ancient cases are to be found in the literature.

Diagnosis of foreign bodies. There are four things to do: First, determine the immediate loss of vision; second, the character of the wound and its direction; third, the kind of foreign body; fourth, its location. It often happens that a patient supposes he has a foreign body in the eye when none exists, or that the object is iron or steel when it may be wood or stone, and thus non-magnetizable.

The history is not fully to be relied upon, as the excitement of the accident, or, in some cases, malingering, will lead to misleading statements of the patient or those who may accompany him. It is well to question the patient as to the circumstances of the accident, the character of the tool and object on which he may have been working and to place him in the position in which he was at the time of the accident. In some cases it is advisable to examine the tool which he was using, as a portion from this generally forms the foreign body.

The visual acuity immediately following the accident does not bear much relation to the prognosis on account of the obscuration of the media by hemorrhage or exudates which may ultimately clear up.

The character and location of the wound is of great importance as to the trauma done by the foreign body; accompanying injuries of the lens and ciliary body are respectively dangerous.

Small wounds are generally due to iron, steel, or copper particles; larger ones to stone, glass, etc.

The direction of the wound canal may be determined by direct and focal illumination and ophthalmoscopy, giving us some idea of the first course of the projectile. The study of the small air bubbles in the course of the wound in fresh cases will show its direction.

Careful probing of the wound with a fine, disinfected sound may give evidence of a foreign body near the surface when the media are obscured, or when the ophthalmoscope does not show the intruder, as when the foreign body lies near the ciliary body. The probe must not be entered into the vitreous except as a part, and at the time, of a magnet operation for a supposed iron or steel chip.

Examination of the visual field, with two lights at a meter distance will show defects in the field as sectors or large scotomas, which may give an idea as to the localization and contraction of the field in a general diagnosis for retained foreign bodies. This contraction is usually above, as the foreign body sinks below.

When the media remain clear enough the perimeter examination may show the scotoma corresponding to the foreign body. Intelligent persons will often entoptically see, and be able to describe, the position of the foreign body.

A symptom of more or less diagnostic and localizing importance is circumscribed redness and pain on touching a spot over or near the foreign body, but it must be remembered that the same symptoms are to be elicited over a cyclitic area.

In no other part of the eye is the prognosis so unfavorable as when the foreign body remains in the vitreous. In but few cases is the object encapsulated, and in fewer still is vision retained. Nearly all cases result in irido-cyclitis, with a large proportion of sympathetic ophthalmitis cases unless the foreign body be speedily removed. In the statistics of cases lost previous to the aseptic era, and that from 1883 to 1886 when the magnet was not used, 83 per cent. were lost. Now there is shown a much less percentage of loss.

Iron splinters give the best prognosis, for they may in many cases be early diagnosed and removed by the magnet operation. In the case of splinters of copper the extraction is very difficult and is seldom accomplished, and in the case of other objects removal practically never happens.

The *treatment of foreign bodies in the vitreous* consists in the care of the wound and the extraction of the foreign body in order to get healing and insure the function of the organ if not too much damaged. Even if the foreign body be removed and no sight be left, the form of the eye should be remembered, as a sightless, good-looking, and non-painful or dangerous orb is better than a prothesis. If the foreign body cannot be removed and the eye be blinded it should be enucleated. If the wound be lacerated and contused and in a dangerous location, as the ciliary region, particularly in working men and in patients who cannot remain under skilled observation, it may be advisable to remove the globe rather than to run the risk of a long course of healing, with the expense and ultimate risk of sympathetic ophthalmitis from neglect or inability to recognize its approach and dangers. See, also, **Vitreous, Foreign bodies in the.**

Hemorrhage into the vitreous occurs in all forms of injury to the vitreous. See **Vitreous, Hemorrhage into the.**

Gunshot injuries of the vitreous. In bullet wounds of the globe, more or less complete loss of vitreous follows. In those from bird shot little or no loss may occur.

Shot grains and portions of other projectiles may remain quiet in the vitreous even without causing sufficient irritation as to become encapsulated, but as a rule they cause inflammation in the uvea and end in atrophia bulbi. Powder grains and pieces of stone carried thence by explosives are noted.

Concussion and contusion of the vitreous is common and complicated by entrance of blood. Opacities and resultant new membranes occur both by direct and indirect injuries from the organization of blood clots resulting from hemorrhages from ruptured retinal, choroidal, or ciliary blood vessels. As a rule other damage is done to the eye, to be discerned as soon as the media clear, as rupture of the choroid and retina, detachments, etc.

The treatment is that of perforating wounds of the posterior part of the eye. It is practically asepsis, and either palliative or radical. The shot may seldom be extracted unless it is found in or near the wound of entrance. In severe injuries enucleation should be practised, and is the principal eye operation for the field surgeon in time of war. See **Military surgery of the eye**; as well as **War** captions.

Degeneration of the vitreous following injuries. The occurrence of vitreal opacities has been a number of times noted in these pages. These result from hemorrhages and exudates, the more minute opacities consisting of masses of cells or pigment granules or filaments, the large become organized into membranes, cords or large masses of connective tissue. A new formation of blood vessels supplying these membranes may take place, running from the retinal vessels into the vitreous, and to be seen by the ophthalmoscope, the so-called retinitis proliferans discussed more fully elsewhere herein.

Liquefaction of the vitreous is a sequel of various conditions, but is constant after chronic cyclitis and union of the ciliary processes; not only this, but the albuminous element is increased. This is due to alterations in the epithelium of the orbicularis ciliaris, permitting the albumin of the blood to penetrate. Various conditions follow this, particularly that known as fibrillary degeneration. In relation to this, as rarely as we have a regeneration of the vitreous fibrillæ, so rarely do we have, either as a result of the inflammation or other degeneration, an hypertrophy, a thickening or an increase of the same. There is no such thing as fibrillary degeneration of the vitreous. The only change the fibrillæ of the vitreous undergo is their solution.—(H. V. W.)

Vitreous, Loss of. See, also, under **Cataract** operations.

One of the methods recently advised to prevent loss of vitreous fluid in operations on the eye is that of Van der Hoeve (*Nederl. Tijdschr.* v. Gen. Nov. 8, 1919) who gives a description of the four thread methods with which he lifts up the anterior wall of the eyeball. The vacuum made by lifting up the wall aspirates back any of the vitreous fluid that is on the point of escaping. Each thread is passed through the outer layers of the cornea, close to the iris, to form four loops with which the two assistants lift up the wall when loss of the fluid is impending. The loops are useful also for other purposes, as he describes. See, also, **Vitreous, Prolapse of the.**

Vitreous, Malformations and anomalies of the. See p. 2911, Vol. IV **(coloboma of the vitreous)**, p. 2921, Vol. IV **(persistent hyaloid artery)** and p. 2929, Vol. IV **(abnormal vitreous vessels)** of this *Encyclopedia.*

Vitreous opacities. These are classified as fixed and floating, and may be acute or chronic. They may appear as fine, dustlike particles (particularly in syphilitic retinitis and choroiditis) or may be threads, bands, dots, membranes, or projections. They vary much in size, shape, and color. The fixed opacities are generally fastened at two or more points.

Opacities of the vitreous result from many different conditions, among which are the following: Errors of refraction, particularly myopia of high degree; inflammation of the retina and uveal tract; traumatisms producing hemorrhages from the ciliary region or choroid; depraved conditions of the general system from low fevers or other exhausting diseases, anemia, loss of sleep, gout, syphilis, menstrual disorders, constipation, portal congestion, malaria, the long-continued use of arsenic, etc. Large fixed opacities may result from trauma and may simulate neoplasms. In many instances opacities of the vitreous are present in persons in whom other affections are not demonstrable; this is particularly true of elderly persons. Under the name asteroid hyalitis Benson has described a condition in which small, light-colored spheres are found in the vitreous. It is probably a congenital condition.

The subjective symptoms of vitreous opacities depend on the number and size of the opaque spots. The patient sees them as black specks floating in the visual field *(muscæ volitantes).* They are particularly annoying when the patient is looking at a bright surface. Visual acuity may or may not be reduced. Reduction of vision, pain, and asthenopic symptoms will cause the surgeon to seek errors of refraction, associated ocular changes, or diseases of the general system.

Vitreous opacities can be seen by using a concave retinoscopy mirror of twenty-five centimetres' focus. Whether the spots are fixed or floating can be determined by having the patient move his eye while under examination. After movement the eye is to be held perfectly quiet. Fixed opacities will remain in situ, while floating ones will be seen to move, and their rate of movement gives an indication of the consistency of the vitreous. In a vitreous body of normal consistency the spots move slowly; in a fluid vitreous the movement is rapid. Vitreous opacities, if floating, move in a direction opposite to the movement of the eye, while opacities in the lens and cornea move in the same direction as the ocular movement. This is because the latter opacities are fixed. By using a + 14 or 16 D. lens, by direct ophthalmoscopy, fixed vitreous opacities can be examined satisfactorily. If the opacities are minute, a plane mirror armed with a strong convex lens should be used, and the pupil should be dilated.

The prognosis in vitreous opacities depends on the cause and on the size and the age of the opacities. Recent opacities may clear entirely; old ones will likely remain in spite of treatment. When resulting from syphilis the opacities readily clear up under proper treatment. If caused by hemorrhage, the clot, if small, will be absorbed; large clots always leave opacities. In opacities caused by purulent choroiditis the prognosis is grave, the eye ending in phthisis bulbi. Muscæ volitantes show no opacities to the ophthalmoscope, and are probably caused by shadows of the remains of embryonic tissue thrown on to the retina. They are exceedingly annoying, and often remain in spite of the correction of refraction errors and attention to the general health. They are not significant of serious lesions.

The treatment of opacities of the vitreous includes the removal of the cause, the regulation of the habits of the individual, and the exhibition of remedies for the purpose of producing absorption. Iodid of potassium, the various preparations of mercury, pilocarpin, and saline laxatives are all valuable measures. The use of the galvanic current, paracentesis of the anterior chamber, and the subconjunctival injection of a 5-per-cent. strength salt solution are among the measures which have been advocated. The intra-ocular injection of various mercurial salts, iodid of potassium, and carbolic acid has been proposed. This method of treatment should be condemned, as it is dangerous to the eye.—(J. M. B.)

See, also, **Muscæ volitantes**, p. 7880, Vol. X of this *Encyclopedia*.

The Editor (*System of Ophthalmic Therapeutics*, p. 780) believes that the treatment of vitreous opacities should be directed first of all to the removal, if possible, of their cause and the prescription of certain remedies known to bring about absorption of them. These are particularly pilocarpine sweats given with large and increasing doses of iodide of potassium and pilocarpine. At the same time saline laxatives and mercurial inunctions are often prescribed with benefit. Subconjunctival injections of normal saline solutions, alternating with the local application of dionin are generally of benefit.

Fuchs (*Text-Book*, p. 467) thinks that saline mineral waters ought to be used in conjunction with other remedies, and that repeated paracentesis of the anterior chamber (to stimulate tissue changes in the eye) may be of service.

The use of galvanism is recommended by several observers.

When the opacities are due to syphilis, or non-penetrating trauma, treatment is of decided value and markedly good results follow the medication just indicated.

In the cloudiness and other opacities due to causes not connected with these conditions, very little benefit ensues. To this it may be added that the hyalitis of myopia and of other refractive errors, including anemia, menstrual disorders and digestive affections are decidedly affected by treatment directed towards a removal or relief of these disorders. The treatment of congenital opacities is by no means satisfactory. Some large, membranous opacities may, as Bull advises, be reached by discission.

Vitreous, Ossification of the. The general subject of bone formation in the eye is discussed on p. 9196, Vol. XII and elsewhere.

True ossification of the body of the vitreous is very rare although a number of cases are on record. For example is a case reported by Vigier (*Oph. Year-Book* 1908) while Vassiliades reports ossification of the hyaloid membrane in a shrunken eye, destroyed ten years before by purulent ophthalmia and panophthalmitis.

Cesar Urraca Y Reyero (*Archivos de Oftalmologia,* June, 1913) details a case of complete ossification of the vitreous. The patient was twenty-six years old, and twenty years earlier had completely lost the vision of the left eye, probably in consequence of corneal ulcer. There had been only slight disturbance in the blind eye during the intervening period, until a month back, when the eye had become sharply inflamed and so painful as to interfere with sleep. Examination showed anterior staphyloma, extensive deep ulceration of the cornea, hypopyon, and iritis. There were also intense photophobia and extreme hyperesthesia. The eye was enucleated and found to be atrophied and of stony hardness. The space normally occupied by the vitreous was filled with an imperfectly rounded body of rough surface and whitish color, weighing 2.3 gm. and measuring 2x1x1 cm. The lens was ossified. The ocular coats, not excepting the choroid, were found microscopically neither ossified nor calcified, but presented merely the changes characteristic of chronic inflammation. The central mass had the histologic structure of true bone.

It must not be forgotten that the possibility of ossification of the vitreous has been denied absolutely by Knapp, though confirmed by Virchow and Hyrtl. The bony tissue in Reyero's case was probably formed by ossification of exudate thrown into the vitreous from the uveal tract, and subsequently organized.

Vitreous, Parasites in the. VITREOUS ENTOZOA. Three kinds of animal parasites have been found in the vitreous body. They are the cysticercus cellulosæ, which is not rare in North Germany, where raw meat is often an article of diet, but is extremely uncommon in France, Austria, England, and America; the filaria sanguinis hominis, which has been observed a few times; and the hydatid cyst, which is of rare occurrence. This subject has already been discussed in the section on **Parasites, Ocular,** p. 9265, Vol. XII; under **Cysticercus cellulosæ,** p. 3660, Vol. V; and under **Echinococcus** *(hydatic cyst),* p. 4123, Vol. VI of this *Encyclopedia.*

A recent account of a case of cysticercus in the vitreous has been recorded in the person of a United States soldier by de Schweinitz and Wiener (*Trans. Oph. Sec., Am. Med. Assocn.,* June, 1919).

Vitreous, Prolapse of the. See **Vitreous, Injuries of the**; as well as under the various **Cataract** headings, especially on p. 1722, Vol. III of this *Encyclopedia.*

Vitreous, Purulent inflammation of the. See **Hyalitis, Purulent.**

Vitreous, Replacement of the. VITREOUS SUBSTITUTION. Most of the work in an attempt to replace lost or diseased vitreous by other material has been done by Römer, Elschnig and Dor. In a paper read before the Oph. Gesellschaft in 1911 Elschnig gave the results of two years' experience in the treatment of various pathological conditions of the vitreous, by removal of a portion of that humor, by means of a syringe, and its replacement by an equal quantity of physiological salt solution. This essay is abstracted in the *Oph. Review,* p. 40, Feb., 1912.

In 1903, as a result of experiments on animals, Römer suggested that hemorrhagic lesions in the vitreous might be treated by a blood serum which was hemolytic to human blood corpuscles. Elschnig's experience of this procedure convinced him that it was not suitable for human eyes. He has since treated a series of cases of disease of the vitreous by the removal of a portion of the abnormal vitreous, and the injection of an equal quantity of salt solution in its place. This may be repeated after an interval of two to three weeks.

Birch-Hirschfeld has already shown that in the eyes of rabbits the removal of vitreous is often followed by detachment of the retina, or by thickening of the tissue of the vitreous.

Loewenstein and Samuels, working in Elschnig's clinic, have removed vitreous, without any compensatory injection, from the eyes of 10 rabbits. The loss of small quantities of vitreous up to 0.3 ccm. was not followed by any bad result. In two cases in which 0.4 ccm. was removed, one showed gross changes in the vitreous; the other retained a clear vitreous.

The removal of more than 0.5 ccm. of vitreous was followed in all cases by hemorrhage into the vitreous, formation of grey membranes in the vitreous, or detachment of the retina.

The results of removal of vitreous and its replacement by salt solution were much more favorable. Immediately after the injection small, lustrous flakes were visible in the vitreous in all cases. Of 6 cases in which 0.5 to 0.8 ccm. of vitreous were removed, in only one was there a rent in, and detachment of, the retina, perhaps from a wound by the canula; in one a circumscribed hemorrhage occurred; in one very fine dust opacities appeared in the vitreous; in three cases the vitreous retained its normal transparency and in one of these 0.8 ccm. had been removed.

By the use of a solution of India-ink it was shown that half an hour after removal of about 0.5 ccm. of vitreous, and the injection of an equal quantity of fluid, the whole vitreous was equally infiltrated by the solution.

Anatomical examination of eyes treated as above and then fixed in Zenker's fluid, showed numerous small spaces in the vitreous filled with clear, slightly albuminous fluid.

Elschnig has employed this method of treatment on 15 eyes, in 14 patients; the conditions were those of dense opacity of vitreous following hemorrhage (disease of vessels and retinitis proliferans) or irido-cyclitis; in one instance traumatic hemophthalmus and infiltration of vitreous, once aseptic, once septic; and in 6 cases detachment of the retina.

In 3 cases (4 eyes) of opacity of the vitreous following hemorrhage, remaining unchanged for many months, so much clearing of the vitreous resulted from this treatment that in each case a good view of the fundus, both by direct and indirect ophthalmoscopic examination, was obtained; the vision, previously limited to perception of light, rose to a degree which was commensurate with the condition of the structures in the anterior segment of the eye, e. g., lenticular degeneration. In one case of retinitis proliferans nearly normal acuity was regained.

The results in cases of vitreous opacity following iridocyclitis were much less favorable, and no benefit occurred in the case of traumatic hemophthalmos. A very transitory improvement occurred in a staphylococcal infection of the vitreous, and a good result in a case of aseptic infiltration of the vitreous after injury by a shot-pellet.

In nearly all instances the injection was well tolerated. In a few of the early cases in which as much as 0.7 to 0.8 ccm. were withdrawn, an iritis with a small hypopyon developed, but it had no effect upon the ultimate good result. In one case, in which there was gross vitreous opacity, possibly associated with retinitis proliferans, iritis and increased tension ensued.

By reason of his clinical observations, and of experiments on animals, the author recommends a trial of this method of treatment in cases of long-standing hemorrhage into the vitreous and of other kinds of advanced vitreous opacity.

Dor (*Oph. Year-Book,* p. 231, 1912), in one case of blindness from vitreous hemorrhage, made two openings in the eye; and, instead of the 0.85 per cent. salt solution, injected into one opening the comparatively fluid vitreous of a horse, while the blood was permitted to escape from the other. The patient remained entirely blind, and two years later the eye thus treated was soft, although the other retained normal tension. We know now by laboratory experience that the tissue of one animal is a dangerous thing to introduce into an animal of another species, and the previous experience of Elschnig had shown the importance of this danger in attempts to replace the vitreous.

Vitreous, Serology of the. Conclusions from the action of sera on the vitreous have been largely drawn from experiments on the lower animals. Among these are the observations of Kuffler (*Oph. Year-Book,* p. 205, 1913) in animals which had been highly immunized, either actively or passively. He found that there may occur a passage of antibodies into the vitreous of the healthy eye. This happens, however, in very small quantities, and the presence of the antibodies cannot be demonstrated in each individual case. The appearance of precipitins could not be ascertained. Agglutinins and hemolysins could only be demonstrated in the vitreous of animals whose serum was immunized in very high degree. The author regards the appearance of bacteriolysins and antitoxins in the vitreous as proved beyond question.

The resistance of the vitreous to various micro-organisms has also been studied by Salus, who found that for a time the number of bacteria experimentally introduced was diminished, probably as the result of the change in nutrient medium. The period of multiplication followed, and when this multiplication had reached a certain height, which varied for different organisms, the intervention of cellular and non-cellular protective bodies began. The peculiar position of the ocular interior as regards resistance to bacterial invasion seems to depend, not on the fact that the protective substances act here too feebly, but that they intervene too late.

Vitreous, Spectrum of the. Images (entoptic phenomena) observed by the individual in his own (normal) vitreous. These are, generally speaking, *muscæ volitantes,* or, rather, such objects as are seen by entoscopy. See p. 4329, Vol. VI of this *Encyclopedia.*

Donders (*Accommodation and Refraction,* p. 197) shows the vitreous spectrum as exhibiting in this way, small, isolated circles; pearly strings, coherent circles, and minute membranes.

Vitreous spheres. See p. 4428, Vol. VI of this *Encyclopedia.*

Vitreous, Tumors of the. Occasionally tumor cells of neoplasms of the choroid, retina or optic nerve are carried into the vitreous body and develop a metastasis there. Parsons says that *glioma endophytum* (see p. 5679, Vol. VII of this *Encyclopedia*) is the commonest form of tumor in which this occurs. See **Tumors of the eye**, herein.

Vitreous vessel formation. The development of new vessels, in the vitreous is a rare condition. The vessels are derived from the retinal system, generally coming from the optic disc, but have been seen springing from the periphery of the retina. After running forward as fine, convoluted branches they form loops and return. Most of the cases on record occurred in syphilitic subjects, and in several of them there were hemorrhages into the vitreous. See the illustration of Harlan's case (*Trans. Am. Ophthalm. Soc.,* 1889).

The only case of new vessel-formation in the vitreous which the writer has seen occurred in a man who attempted suicide, but succeeded only in passing the bullet through both orbits. The optic nerve on one side was severed close to the globe. In this eye an intense papillitis and abundant vitreous hemorrhage was followed by the formation of a large opaque mass in the posterior pole and the subsequent development of new vessels. In some of the reported cases, under antisyphilitic remedies, the exudation has cleared and many of the vessels have disappeared. In a case recorded by Hirschberg a bluish mass of connective tissue was situated on the disc, hiding the exit of the vessels, while a vascular web, likened to the framework of a fly's wing, extended upward and inward.

The treatment of this rare condition consists in the internal administration of mercurials and iodids.—(J. M. B.)

Dunn (*Oph. Year-Book,* p. 229, 1912) has reported a case, watched for more than a year, in which the vitreous twice became so full of exudate as to give a dark reflex and preclude seeing the fundus details. When first seen there were dust-like opacities and peculiar vascular fibrinous masses extending forward 8 D. These masses consisted of semi-transparent whitish glistening exudate, containing great numbers of blood vessels, varying in size from the largest retinal arteries to those barely visible. The vessels anastomosed freely, many of the branches ending in knobs, which consisted of the terminal twigs winding upon themselves. A few small hemorrhages were noted. The vessels were seen to extend and form new loops. The second eye became similarly involved. Mercury and large doses of potassium iodid were given. At the end of ten months the eyes seemed doomed; but three months after that the vision of the eye first affected was noted as "excellent." In the other eye the vascular tufts were still increasing; and were reaching almost to the posterior surface of the lens.

Persistent hyaloid artery and similar *congenital* conditions have been discussed under **Vitreous, Malformations of the,** and under other captions elsewhere in this *Encyclopedia.*

Vitrescent. Turning into glass; tending to become glassy; hyalescent.

Vitreum. The *corpus vitreum* or vitreous humor of the eye.

Vitrics. (a) The study or history of glass and glass manufacture. (b) Glass and glassy materials in general.

Vitriol, blue. See **Copper sulphate,** p. 3314, Vol. V of this *Encyclopedia.*

Vitriol de cuivre. (F.) Copper sulphate.

Vitriolum album. See **Zinc sulphate.**

Vitriol, White. See **Zinc sulphate.**

Vittadini, Angelo. An Italian surgeon and physiologist, who devoted considerable attention to the physiology of the eye. Born at Pavia Aug. 21, 1802, he there received his medical degree in 1824, there practised and there taught, for a good many years, surgery, pathology, materia medica, and, later, higher anatomy and physics. He became professor emeritus in 1862, and died April 18, 1874. Vittadini's writings are as follows: 1. *Osservazioni ed Esperimenti sulla Vista e sul Gusto.* (Milan, 1853.) 2. *Teoria Fisiologica della Visione,* etc. (Pavia, 1854.) 3. *Memoria sul Meccanismo della Visione.* (Pavia, 1862.)—(T. H. S.)

Vleminck, Jean François. A well-known Belgian physician and ophthalmologist. Born at Brussels, Nov. 30, 1800, he received his medical degree at Lyons in 1822, and then for about a year he studied in Paris, devoting his attention chiefly but not exclusively to ophthalmology. Returning to Brussels, he practised both as internist and as ophthalmologist. Among his more important ophthalmologic writings were: *"Notices sur l'Ophthalmie de l'Armée"* and *"Essai sur l'Ophthalmie des Pays-Bas"* (Brussels, 1825.) He was for twenty-six years a collaborator on the *"Arch. de Méd. Belge."* He died Mar. 18, 1876.—(T. H. S.)

Vocational disability. As Lloyd Mills (*Journ. Am. Med. Assocn.*, Sept. 2, 1916) and many others have shown, abnormal ocular affections (and especially eye strain) bring about a large percentage of vocational disability. This occurs among those that use their accommodation to excess—stenographers, students, teachers, bookkeepers, seamstresses, milliners, *et al*—types of workers who can least well afford the disability from the economic standpoint. See **Occupational diseases,** p. 8466, Vol. XI of this *Encyclopedia;* also under **Care of the eyes.**

Vocational reeducation of the blinded. See **Reeducation of the blinded,** p. 10899, Vol. XIV of this *Encyclopedia.*

Vogel, Samuel Gottlieb von. Son of Rodolph Augustus V., and himself a well-known internist, who wrote a treatise on hemeralopia (Loder's *Jour. f. Chir.*, I, 1797). Vogel was born at Erfurt, Mar. 14, 1750, received his medical degree at Göttingen, practised in various German towns and cities, chiefly Rostock, and died of influenza, Jan. 19, 1837.—(T. H. S.)

Vogel, Zacharias. A well-known German surgeon, especially celebrated as a herniotomist and cataract operator. The date and place of his birth are not known. He practised at Lübeck, and there died April 18, 1772.

His only ophthalmologic writing was entitled *"De Lente Crystallina Extracta per Corneæ Aperturam."*—(T. H. S.)

Vogler, Johann Heinrich Christoph. A well-known German surgeon, who devoted considerable attention to diseases of the eye. Born Mar. 5, 1772, at Hesse in Braunschweig, the son of a surgeon, he received his medical degree in 1795 at Helmstaedt. His dissertation on this occasion was entitled *"De Maculis ante Oculos Volantibus"*—the only ophthalmologic writing which he ever published. He practised for a time in Hesse, then in Helmstaedt. Late in life, he became hard of hearing, gave up practice, and founded, together with Dr. Wilhelm Koerte, a Book and Art Store. Still later, he removed to Potsdam, where he continued in the book trade. He died Feb. 3, 1836.—(T. H. S.)

Vogtherr, of Strassburg. He published in 1538 a popular work, entitled *"Ein Neues Hochnützliches Büchlein von Erkenntniss der Krankheiten der Augen."*—(T. H. S.)

Voir. (F.) To see.

Voit, Gottlob Wilhelm. A German physician, who paid considerable attention to ophthalmology. Born in 1787, he received his medical degree in 1809 at Landshut, and practised for a very short time at Schwenfurth. He died June 12, 1813, aged only 26.

Voit's only ophthalmologic writing was entitled *"Comment. Med.-*

Chir. Exhibens Oculi Humani Anatomiam et Pathologiam, ejusdemque in Statu Morboso Extirpationem" (Nürnb., 1810).—(T. H. S.)

Volkmann, Alfred Wilhelm. A celebrated German physiologist, who paid considerable attention to the physiology of the eye. Born at Leipsic, July 1, 1800, he there received his medical degree in 1826. After a number of scientific journeys to French and English universities, he qualified in 1828 as privatdocent at the Leipsic University, in 1834 became professor extraordinarius of zootomy, and in 1837 was called as professor of physiology, pathology, and semiotics to Dorpat. In 1843 he was made professor in ordinary for physiology at Halle. He was widely known for the clearness and thoroughness of his teaching. He died April 21, 1877.

Volkmann's ophthalmologic writings are as follows: 1. *Neue Beiträge zur Physiologie des Gesichtssinnes.* (Leipsic, 1836.) 2. *Physiologische Untersuchung im Gebiet der Optik.* (2 Hefte, Leipsic, 1863-'64.)—(T. H. S.)

Volkmann, Discs of. See p. 4034, Vol. VI of this *Encyclopedia.*

Volpi, Tommaso. An Italian surgeon, who published a work on the fistula lacrimalis. He was born in 1761, became a pupil of Scarpa, practised at Pavia, and died in 1822.—(T. H. S.)

Voluntary inhibition. The voluntary restraint of reflex actions, such as the arrest of winking when the eyeball is touched.

Voluntary iris. Avian iris. This term is applied to those rare cases in which, without change in convergence or accommodation, the individual can, *like most birds,* (see **Bird's iris,** p. 982, Vol. II) contract and dilate the iris at will.

Volution. A twist; a spiral turn.

Volvelle. (F.) A pair of lantern transparencies or other designs superposed and movable one over the other for the purpose of showing variations.

Voorhies, A. H. An American ophthalmologist, widely known for his cataract operations. Born of Dutch-American ancestry, he received his medical degree from the University of Pennsylvania, Mar. 15, 1860, and served for a time in the Pennsylvania Hospital. Throughout the Civil War he served in a surgical capacity, and, at the expiration of the conflict, went to Paris for the study of ophthalmology. He settled in San Francisco in 1881.

As has been well said, "Dr. Voorhies created for himself a specialty within a specialty. That is to say, he devoted himself assiduously to the cataract operation, and for fifteen or twenty years is declared to have extracted far more cataracts than all his brother ophthalmologists in San Francisco."

He wrote but little, being almost exclusively an operator. He was a man of the utmost purity of character, and of a fine, old-fashioned, stately courtesy. A correspondent writes, "His placid self-command was a blessing to nervous patients, who relied upon him instinctively." He died in San Francisco, May 5, 1908.—(T. H. S.)

Vordere Augenkammer. (G.) Anterior chamber of the eye.

Vorfall. (G.) Prolapse.

Vorlagerung. (G.) Advancement.

Vortex lentis. Star-like or spiral figures seen on the surface of the crystalline lens.

Vortex veins. See **Venæ vorticosæ.**

Vossius ring. See **Cataract, Vossius annular,** p. 1769, Vol. III of this *Encyclopedia.*

Vossius's test for feigned blindness. See p. 1188, Vol. II of this *Encyclopedia.*

Vuerometer. An instrument for measuring the distance of the eyes from each other. A pupilometer.

Vulture, The. The gall of a vulture, mixed with Attic honey and marrubium juice, was highly esteemed in ancient Greco-Roman times as a remedy for many diseases of the eye, especially incipient "hypochyma" (the modern "cataract"). In nyctalopia the broiled liver of a vulture was often employed. (See **Nyctalopia, History of the Term.**)—(T. H. S.)

W

W. The chemic symbol for Tungsten or Wolfram.

Wagner, Carl Wilhelm Ulrich. A celebrated medico-jurisprudentist and ophthalmologist. Born at Berlin, Jan. 21, 1793, as the son of the distinguished philosopher, Carl Franz Christian Wagner, he studied at first with his father, later at Braunschweig, Marlburg, and Göttingen. At the last-named institution he received his Doctor of Medicine in 1813. For a time he engaged in military practise, then became professor of State Medicine at Berlin.

His most important writings are: *"Commentatio de Foeminarum in Graviditate Mutationibus, nec non de Causis, quibus Fiat ut Integro earum Valetudo cum hisce Mutationibus,"* etc. (Braunschweig, 1816); *"De Medicorum Juribus atque officiis Tractatus"* (Berlin, 1819); *"A few Words concerning Dr. Schlagintweit's Expressions about my Instrument for the Formation of the Artificial Pupil"; "Concerning the Diseases of the Chorioidea"; "A Few Remarks Concerning the So-Called Coloboma of the Iris."* The three last-named compositions are journal articles.

Wagner is especially memorable because of his invention of the three terms—iridotomia, iridectomia, and iridodialysis. These he first proposed in his "*Commentatio de Coremorphosi,*" which appeared at Göttingen in 1818. Cheselden, who invented the artificial pupil about 1727, called his procedure, simply, "incision thro' the iris." Shortly afterwards came into use the expressions: Coretomia, Corektomia, Coredialysis, Coretotomie, Coretonektomie, Coretodialysis. Wagner's three expressions were offered by him as decided improvements on all these very undesirable terms. It is hardly necessary to add that Wagner's terms supplanted the others very promptly and permanently.

Wagner died Dec. 4, 1846.—(T. H. S.)

Wagner, Karl Ernst Albrecht. A celebrated German surgeon, of a slight importance in ophthalmology. Born June 3, 1827, son of Carl Wilhelm Ulrich Wagner, he received his medical degree at Berlin in 1848, and, the following year, entered the army in a surgical capacity. Having served till the end of the Schleswig-Holstein war, he studied for a time at Paris and Vienna, and became assistant to von Langenbeck. In 1853 he was called to the chief surgeoncy at the City Hospital, Dantzic, five years later, however, to the full professorship of surgery and the directorship of the Surgical Clinic at Königsberg. Entered again into active military service, he was stricken with typhus at Dôle, where he died Feb. 15, 1871.

His only ophthalmologic writing was "Ueber Amblyopie und Amaurose bei Bright'scher Nierenkrankh." (Virchow's *Archiv,* IX, 1856). —(T. H. S.)

Wagner, Philip Matthew. A well-known ophthalmologist and oto-laryngologist of Canal Dover, Ohio. Born at Sandyville, Ohio, son of Christian and Matilda (Phersig) Wagner, in 1868, he received the medical degree at Ohio Medical University in 1896. After some years spent in general practice, he turned his attention to ophthalmology and oto-laryngology and settled as a specialist in these branches at Canal Dover. He was a Republican, and took a prominent part in politics, being, for example, a member of the Seventy-Sixth General Assembly. In 1914, while studying in Berlin, he was taken ill with cholelithiasis, and, before the close of the operation for this condition, died, July 24, aged 46.—(T. H. S.)

Wagner's disease. See **Corkscrew vessels,** p. 3331, Vol. V, as well as under **Polycythemia,** p. 10308, Vol. XIII of this *Encyclopedia.*

Wahlbom, Johan Gustaf. A celebrated Swedish surgeon, renowned especially for his operative dexterity in the extraction of cataract. Born at Nerike, Sweden, Jan. 7, 1724, he received his medical degree in 1751 at Upsala. He became professor of surgery *seriatim* at Upsala, Lund and Stockholm. Later, he studied in Germany, and, returning to Sweden, became physician-of-the-Province in Kalmar. He died Jan. 25, 1807.

In addition to books and articles of a general medical and surgical character, he wrote "*Skrifträxling om alla Brukliga Sätt att Operera Starren på ögonen.*" (Stockholm, 1766.)—(T. H. S.)

Wahrnemung. (G.) Perception.

Wainewright, Benjamin. A well-known English ophthalmologist, who was born in 1853 and who died suddenly of heart disease at Pontresina, Switzerland, Aug. 28, 1910. He was once assistant surgeon to the Royal Westminster Ophthalmic Hospital, and was winning considerable reputation, but, being wealthy, retired from practice a number of years before his death.—(T. H. S.)

Wainscoted fundus. The appearance in pigment degeneration of the retina associated with alterations in the latter, together with the superficial choroiditis commonly present with it.

Wait, Wm. B. An American to whom we are indebted for most of the improvements in the New York point print for the use of the sightless. See **Alphabets for the blind.**

Wälchlis's doctrine. That chromoplane (cone pigment) is a postmortem product.

Waldhauer, Karl. A Russian ophthalmologist of great promise which failed of fulfillment because of severe disease of his own eyes. He was born Dec. 20, 1820, at Sallenen, in Kurland, and was for some years a pupil of von Graefe. In 1858 he settled as ophthalmologist at Riga, Russia, and from 1863-1879 was director of the Widow Reimers' Eye Hospital. Later, he removed to Mitau, but, soon after his arrival, was forced to retire from practice because of his own serious eye disease. From this he never recovered, but in fact eventually became wholly blind. He was a very kind-hearted, charitable man, and educated a number of oculists at his own expense.—(T. H. S.)

Waldschmidt, Johann Jakob. Born at Rudelsheim, Germany, he studied at Giessen and a number of other universities, and, in 1667, having returned to Giessen, there received his medical degree. He became professor of medicine and physics at Marburg, and died Aug. 12, 1687. He wrote a number of works in which ophthalmic observations appear. He incorrectly ascribed the phenomena known as *muscæ volitantes,* or *mouches volantes,* to bodies afloat in the aqueous.—(T. H. S.)

Walker, Arthur Nimmo. A well-known Liverpool ophthalmologist, son of the founder of St. Paul's Eye and Ear Hospital, George Edward

Walker. He served in the Boer War and also in the World War, being killed in action Sep. 24, 1916.

Says a writer in "*The Ophthalmoscope,*" Dec., 1916: "Walker's life-work, like that of his father before him, centered around St. Paul's Hospital. Owing to his energy, he got the institution rebuilt, and converted it from an institution for eyes and ears into one for eyes, pure and simple. But that was not his greatest achievement. To the great benefit of the poor of Liverpool, he instituted wards to accommodate babies suffering from ophthalmia, together with their mothers, thereby setting an example that might well be followed by other large towns. He was deeply interested in every aspect of ophthalmia neonatorium, and established the closest relationship between his hospital and the City Health Authorities, with a view both to preventing the disease and to curing it when it had once declared itself. Among the appointments held by Walker was that of surgeon to St. Paul's Eye Hospital, ophthalmic surgeon to the David Lewis Northern Hospital, surgeon to the School for the Indigent Blind, and assistant lecturer in anatomy in the University of Liverpool." —(T. H. S.)

Walker, George Edward. A well-known English surgeon and ophthalmologist, founder of the Liverpool Dispensary for Eye Patients. Born at Wigan in 1840, he studied at University College, London, was clinical assistant of Sir William Bowman at the Royal London Ophthalmic Hospital (Moorfields) and settled, in 1870, at Liverpool. Here he founded the dispensary above mentioned, which from small beginnings soon became the St. Paul's Eye and Ear Hospital, with 50 beds and 10,000 patients yearly. In this institution he worked with unremitting industry for almost forty years. He was also surgeon to the School for the Indigent Blind, and the Hospital for Diseases of the Skin—all in Liverpool. He died at Las Palmas, Grand Canary Island, whither he had gone in search of health, Feb. 25, 1909, leaving a widow and six children.

Walker's chief ophthalmic writing was entitled "*Essays in Ophthalmology*" (239 pp. London, 1879).—(T. H. S.)

Walker, John. A well-known British ophthalmologist, who, for years, was active in the Manchester Eye Infirmary. The date of his birth is not known; his death, however, occurred in 1847.

Walker's ophthalmic writings are as follows: 1. Congenital Deficiency of Both Eyes. (*Lancet,* XXII, 1832.) 2. Stimulant Treatment of Purulent Ophthalmia. (*Lancet,* XXV, 1833, 4.) 4. On the Relation Between Iris and Palpebræ. (*London Med. Gaz.*, 1834.) 4. *Principles of Ophthalmic Surgery.* (London, 1834.) 5. *The Philosophy of* *the Eye.* (pp. 293, London, 1837.) 6. *Course of Lectures on Diseases of the Eye.* (1839, 40.) 7. *The Oculist's Vademecum.* (London, 1843.) 8. The Formation of a New Pupil by Displacement of the Natural One. (*Provincial Med. & Surg. Jour.*, August, 1843.)—(T. H. S.)

Walker's operation. Hyposcleral cyclotomy for glaucoma (*q. v.*).

Walker, Thomas Shadford. A celebrated English ophthalmologist. Born about 1834 at Burslem, Staffordshire, he studied at King's College Hospital, London, later became a Member of the Royal College of Surgeons, and shortly afterward assistant surgeon and surgeon at the Eye and Ear Infirmary, where he labored with great success for almost twenty years. He was also for a number of years instructor in ophthalmic medicine and surgery at the Medical Faculty of University College. He was a man of many interests, was president of the Art Club in Liverpool (as well as one of the founders thereof), and possessed a large and choice collection of art objects, especially Wedgwood ware. He died Sept. 28, 1885.

His writings, all of which were ophthalmologic, were as follows: 1. On Ulcers of the Cornea. (*Liverpool Med. & Surg. Reports,* IV.) 2. Glaucoma. (*Ibid.*) 3. Rare Form of Injury to the Eyes. (*Manchester and Liverpool Medical and Surgical Reports,* 1876.) 4. Peculiar Case of Injury to the Retina and Choroid. (*Ibid,* 1880.)—(T. H. S.)

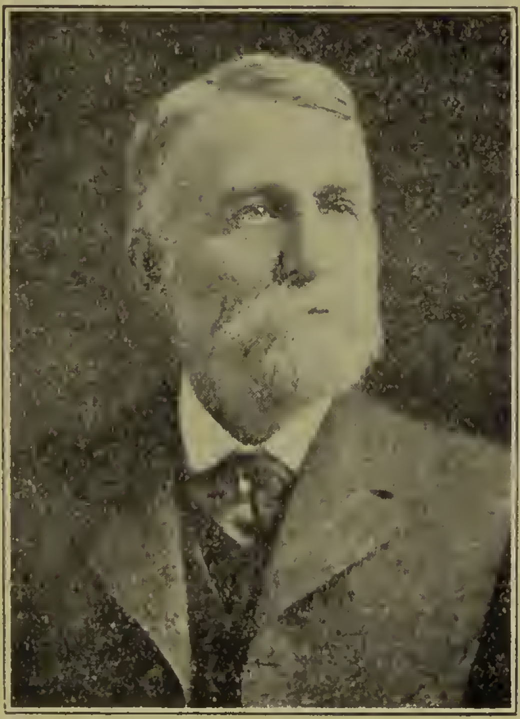
Walker, William. A celebrated Scotch ophthalmologist, concerning whom (very strangely) but little is now known. Born in 1814, he died in 1884, aged 70. For 33 years he was ophthalmic surgeon to the Royal Hospital in Edinburgh; he was also ophthalmologist to the Queen of Scotland.—(T. H. S.)

Walking, Vision in. See **Visual space perception.**

Wallace, James Philip. A well-known American ophthalmologist, brother of Franklin E. Wallace, ophthalmologist of Pueblo, Colorado. Born at Lafayette, Indiana, Feb. 25, 1841, he received his medical degree at Jefferson Medical College in 1864. Entering the army, he served till the end of the War as assistant surgeon. He then matriculated at Bellevue Medical College, from which institution he received the degree of M.D. *ad eundem* in 1866 or '67. Having studied the eye, ear, nose and throat, both in New York and in London, he practised as ophthalmologist and oto-laryngologist for a number of years at Lafayette, Ind. In 1876, however, on account of tuberculosis, he removed to Colorado, where he practised chiefly general medicine.

Little by little he turned his attention to mining, and in 1889 gave up medicine entirely. He wrote a book entitled *"Ore Deposits"* which was published in 1910 by the Hill Publishing Company, of New York City, and which is said to be a highly useful work. One of his most important mining enterprises was the driving of the Nelson Tunnel at Creede, Colo., into Bachelor mountain—a procedure undertaken for the draining of the mines above and also of tapping the Bachelor vein. He was also greatly interested in onion culture, and made a number of important discoveries with relation to that subject.

Early in 1910 Wallace went to Culiacan, Old Mexico, where for a time he operated in mines and lands. Soon, however, becoming afflicted with acute Bright's disease, he attempted to return to Colorado, but died at Nogales, Arizona, June 19, 1910.



James Philip Wallace.

Dr. Wallace was a man of impressive appearance, also of the highest moral character. He was five feet ten inches tall, slim, broad shouldered, and weighed 140 pounds. He was very light and athletic, and, although somewhat retiring in his disposition, was a pleasant companion and a well loved friend. He was, in fact, a friend not merely of people, but also of the lower animals, and many of the dogs and horses in the community in which he lived were well acquainted with him and very fond of him. He was an ardent Christian, a member of the Presbyterian Church from early boyhood till his death.—(T. H. S.)

Wallace, William Clay. An early American surgeon, of considerable importance in ophthalmology because of his skill as an operator and because of his writings on the comparative anatomy of the eye. The dates of his birth and death are not known. He practised, however, as oculist in New York City for a number of years. He published in 1836 the first edition of his little book, and, in 1839, a second, and in 1841 a third. The title of the first edition is not known, that of the second is *"A Treatise on the Eye, containing the Discoveries of the Cause of Near and Far Sightedness, and of the Affections of the Retina, with Remarks on the Use of Medicines as Substitutes for Spectacles."* The title of the third edition was *"Wonders of Vision. A Treatise on the Eye."* In 1850 he published a very small (duodecimo) of thirty-six pages, entitled *"The Accommodation of the Eye to Distances."* This book contains original matter of some value.—(T. H. S.)

Wall-eye. A condition in which (a) the iris is whitish, (b) the cornea shows an opacity or (c) there is divergence of one eye. The wall-eyed pike is a fish "with a large staring eye."

Wall paper. See **Interior decoration,** p. 6532, Vol. IX of this *Encyclopedia.*

Wall-paper experiment. This is the socalled (German) *Tapeten bilder* and is described by Burch (*Phys. Optics,* p. 71) as follows: Use as object a wall-paper with some well-defined simple pattern, repeating itself every foot; or, better, every 6 inches. Placing yourself in front of it at some distance—3 or 4 yards—direct your eyes to some small object, e.g. a bead on a wire, that can be gradually brought nearer. The convergence of the axes of the eyes causes the more distant image of the paper to double, the separation increasing until the pattern overlaps by an entire unit, when quite suddenly the two images will appear to fuse into one much nearer than the wall and also much smaller than the original.

If you continue to move the object nearer, the images will again double, the overlap will increase until it amounts to two units of pattern, when there will be a sudden fusion and fitting together of the pattern which will look still smaller and nearer.

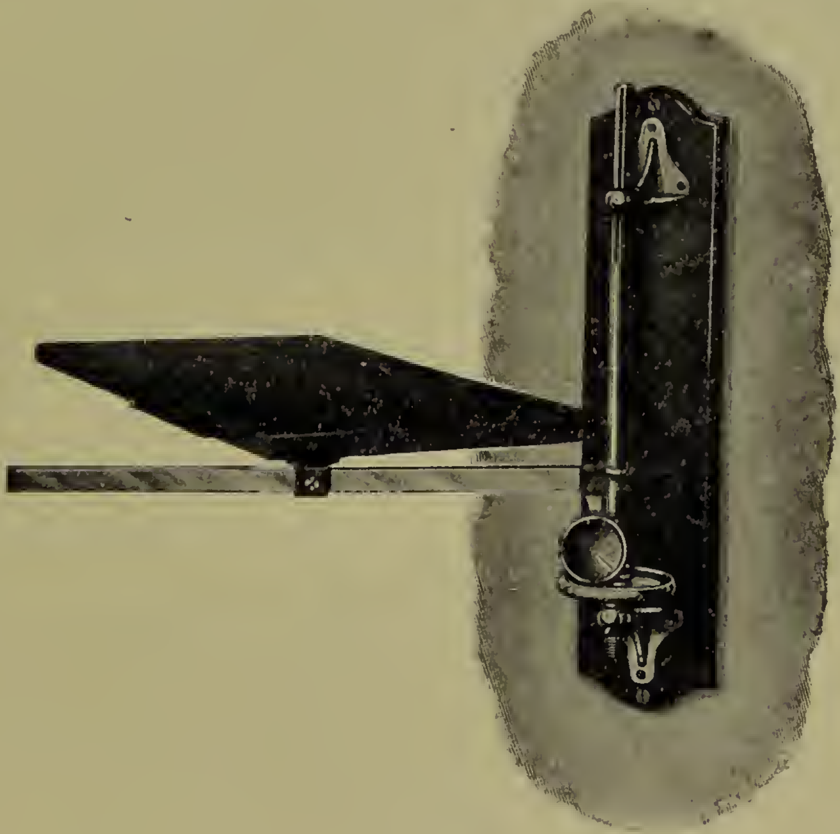
The process may be repeated until three or four overlaps have been noted. But by this time the observer will probably realize that he is squinting badly and that the effort is painfully fatiguing.

It is interesting to note how the mind, misled by the muscular effort of convergence, judges the distance of the images accordingly, taking no heed of the fact that the focusing does not correspond with the con vergence. But it is this lack of correspondence that causes the sensation of fatigue.

The phenomenon is one that many children find out for themselves—the present writer remembers doing so when seven years old, and he has come across many other cases.

Wall-pepper. An ancient remedy for certain eye diseases. See **House-leek.**

Wall table. One of the numerous but useful adjuncts to hospital and office work of the surgeon. One of these is depicted in the text.



Wall Table.

Walnut, English. EUROPEAN WALNUT. NUX REGIA. The leaves and green shells of Juglans regia are used in medicine. They contain tannin, a volatile oil, mucin and extractive matters. A decoction of the shells has for many years been popular in Europe as an application to "sore eyes"—acute and chronic blepharoconjunctivitis especially. In the same way a few drops of the fluid extract, diluted with 10 to 50 times their weight of water, have been prescribed as a lotion in all forms of conjunctivitis.

Walter, Albert G. A German-American orthopedist, lithotomist, and ophthalmologist, known especially for having been the first (Jan. 12,

1859) to open the abdomen for rupture of the bladder and even the first to perform a laparotomy for any kind of injury. Born in Germany in 1811, he received his medical degree at Königsberg, took one year of further study at Berlin, and then removed to America. For the first two years he practised at Nashville, Tenn., then removed to Pittsburg, where he practised until his death in 1876. He never gave up general surgery, but was widely known as an operator on the eye, especially for strabismus and cataract.—(T. H. S.)

Walther, Philipp Franz von. A famous German surgeon and ophthalmologist. Born Jan. 3, 1782, at Burweiler, in the Rhenish Palatinate, he studied his profession at Heidelberg, Vienna and Landshut, at the latter institution receiving his degree in 1803. Almost immediately afterward, though only 21 years old, he was appointed medical councillor, ordinary professor, and chief surgeon to the hospital in Bamberg. Later he studied in Paris, and, in 1804, was made professor of physiology and surgery in Landshut, in both of which subjects, but especially in the latter, he speedily became famous. In 1811 he was made "Rector Magnificus."

Five years later he accepted a call to Halle, but the following year removed to Heidelberg, and, one year later still, accepted the chair of surgery and ophthalmology at Bonn. Here it was that von Walter attained the acme of his career. Famous instructors from every portion of the civilized world came to listen to his eloquence and to profit by his learning and didactic skill. Patients, too, came thronging to him from equally long distances. Seitz declares that he was at that time easily the first of living German surgeons. During his professorate at Bonn, too, it was that, in conjunction with von Graefe, he began to publish (in 1820) the justly celebrated "*Journal für Chirurgie und Augenheilkunde.*"

In 1830 he returned to Landshut, where, once more, he taught, and where, also, he became privy councillor and body physician to King Ludwig I. Here he continued to labor at his various activities until his death, which occurred Dec. 29, 1849, after a few days' illness from abdominal typhus.

Von Walther's chief ophthalmologic writings are as follows: 1. Versuche mit dem Galvanismus an den Augen eben guillotinirter Menschen. (*Salzburger med. Z.*, 1803, Nr. 97; *Ophth. Bibl.* 1804, II, 2, 200.) 2. *Merkwürdige Heilung eines Eiter-Auges Nebst Bemerkungen über die Operation des Hypopyon.* (Landshut, 1805; 2d ed., Landshut, 1819.) 3. *Abhandl. aus dem Gebiet der prakt. Med., besonders der Chir. u. Augenheilkunde.* (1st vol., Landshut, 1810, the 2d vol. never appeared.) 4. Ueber die Steinigen Concretionen der

Thränenflüssigkeit. (*J. d. Ch. u. A.* 1820, I, S. 163-169.) 5. Ueber die Contagiöse Augen-Entzündung am Nieder-Rhein. (*Ibid.,* Vol. II, p. 36-165, 1821.) 6. Ueber die Krankheiten des Ciliarnerven-Systems im Menschlichen Auge. (*Ibid.,* III, 1822, p. 1-45.) 7. Ectropium Anguli Externi, eine neue Augenkrankheit, und die Tarsoraphie, eine neue Augen-Operation. (*Ibid.,* 1826, Vol. IX.) 8. Ueber einen bisher noch nicht Beschriebenen Bildungsfehler der Regenbogenhaut nebst Bemerkungen über Angeborene Missbildungen Uberhaupt. (*Ibid.,* II, 598-615.) 9. Reisebemerkungen aus London, 1830. (*Ibid.,* XV., p. 173-290.) 10. Ueber Amaurose nach Superciliar-Verletzungen. (*Ibid.,* 1840, Vol. 29.) 11. Ueber Pathol. u. Therapie der Amaurose. (*Ibid.,* 1841, Vol. 30.) 12. Ueber die Hornhautflecke. (*Ibid.,* 1845, Vol. 34, p. 1-90.) 13. *Lehre von den Augenkrankheiten.* (2 vols., 1849.)—(T. H. S.)

Walton, H. Haynes. A celebrated London surgeon, especially renowned in diseases of the eye. Born in 1816, he studied at St. Bartholomew's Hospital, London, and in Paris. He became, successively, surgeon at the St. Pancras Royal General Dispensary, at the Central London Ophthalmic Hospital, and in the ophthalmic division of St. Mary's Hospital. In the latter institution he was also instructor in anatomy, operative surgery, and ophthalmology. He was one of the founders of the Central London Ophthalmic Hospital, and labored unremittingly in that excellent institution for more than 26 years. He became in 1848 a Fellow of the Royal College of Surgeons; and died in 1889.

In addition to works of a general, and very useful, character, Walton wrote: 1. *A Practical Treatise on the Diseases of the Eye.* (London, 1852, 3d ed., London, 1875.) 2. *Operative Ophthalmic Surgery.* (London, 1853.) 3. Observations of Ophthalmic Surgery. (A series of articles in the *Medical Times.*) 4. Lectures on General and Ophthalmic Surgery. (*British Medical Journal.*)—(T. H. S.)

Wandering cells. Motile corpuscles. Those that are not fixed within the cell-space, as in the case of the wondering cells of the cornea. See p. 5949, Vol. VIII of this *Encyclopedia.*

Wandering pupil. A term applied by Erlenmeyer (*Ophthalmic Year-Book,* p. 164, 1912) to a unique case. The patient was a woman of 48 years, with some general symptoms pointing to hysteria, and a light grade of coronary and aortic sclerosis. The left cornea was very insensitive, and the left visual field showed a concentric narrowing of about 30 degrees. The patient always had a distinct consciousness of the onset and conclusion of the pupillary seizures, which lasted from ten to twenty seconds and were sometimes repeated several times a day. Vision was blurred during the attacks. The left eye was the one more frequently affected. During the seizure the shape of the pupil constantly changed, as the result of slow fluctuations in the position of various parts of the inner margin of the pupil. The pupil was sometimes vertically, sometimes obliquely oval, or again club-shaped; and assumed eccentric positions.

War. Injury to trigeminus. See **Trigeminal nerve.** Uhthoff's two cases

War. Siderosis as the result of war wounds. See end of section, **Siderosis.**

War, Ophthalmic medicine and surgery in. This section is to be regarded as supplementary to that dealing with the **Military surgery of the eye,** p. 7706, Vol. X of this *Encyclopedia*, and should be read in conjunction with or as introductory to it. The latter caption is complete to 1917; the present section carries the subject to 1921. There are, also, other rubrics that have an indirect value to students of military ophthalmology, among which are such headings as **Trench nephritis**; **Injuries of the eye**; **Shock amblyopia**; **Choked disk**; **Toxic amblyopia** (*e. g. mustard gas*); **Hysteria**, etc.

A study of the essential features of military ophthalmology would have a value largely historical and academic if the recent World War were the last of all great wars.

The characteristics of nations are not suppressed by fiat, however, and while the moral lessons of the recent war are plain to the man of faith, it is altogether likely that they have made no deep or lasting impression, save, perhaps, among the few nations whose aims have always been humanitarian rather than selfish, and among whom education has been primarily a means of individual betterment of character, of "soul" and of personal responsibility under the law. Among those peoples whose educational opportunities or ideals are still greatly defective, unchanged racial hatreds and jealousies exist, sometimes exaggerated by recent bitter memories, and despite the attempted guardianship of more stable nations, it is conceivable that combinations of these essentially less civilized states may again and again sweep the world in holocaustic orgies compared with which those we have been the late witnesses would appear to be elementary and insignificant.

The means for world domination or destruction by some such atavistically ambitious nation are already at hand in the chemical, electrical, explosive, aerial, and bacterial agents developed at the close of the war. With the manufacture of enormous quantities of suffocative and caustic gases, far more lethal than the cruel originators of the torturesome gas-weapon had ever dreamed of evolving, with the means of projecting electrical energy and of controlling it while so projected, with quantity production of Lewisite, the most terrible explosive yet devised, and, finally, with the development of fleets of relatively non-destructible giant dirigibles buoyed by the non-inflammable gas helium, the stage is set for fresh cataclysmic horrors. In such an event the gross lesions of the war just passed will be duplicated, if not greatly exaggerated, by the greater involvement of civilian populations in this wholesale destruction. The knowledge already won, as to the essentials of military wounds and diseases and their treatment, is indelible, however, and the vain and terrible wastage of man-power from infection, which characterized the initial stages of this war, should never be repeated.

For the first time in war, medicine has "come to its own" and the recognition of its basic importance in war, at first not admitted or unwillingly so, by most officers of the line, has at last been made universal as the result of the magnitude of its accomplishments in human salvage, an actual military accomplishment not unequal to that of any other arm of the service.

In the conquest of infection and disease, in the prevention or amelioration of lasting disabilities, and in the practical triumphs of the later humane reconstruction work, ophthalmology has played a gallant part and in the deeds of her devotees has as completely vindicated the principles of specialization in medicine as has been done in the sister specialties of neurology, psychiatry, and cerebral surgery. In fact, it may be said without exaggeration that one of the outstanding medical lessons taught by the war is the elementary necessity of the specialties.

For a study of the fundamentals of military surgical practice and of military ophthalmology in particular, the reader is referred to the author's essay on **Military surgery of the eye,** Vol. X, p. 7706 herein, which covers succinctly the details of military ophthalmology as commonly understood and practised up to 1917. The present work, designed merely to supplement the earlier essay, brings the subject up to date, and intentionally omits restatements of fundamentals, dwelling, instead, upon the important confirmations or modifications of the earlier conceptions and practice, such as those which have taken place in our understanding of military infections and their treatment, of the effects of "gassing," of the advances of plastic surgery of the visual tracts and pathways, and finally, of the sursurgery of the orbit and lids, of the notable improvements of the passing importance of the eyes to aviation.

ORGANIZATION OF THE OPHTHALMIC SERVICE.

Medical and surgical specialization was developed for the first time in this war and its benefits have been so incalculably great that its permanence is assured. It is clear, however, that a specialty like ophthalmology, which serves about one man in every ten on active service, whether it be for the treatment of wounds or infections or diseases of the eyes, or for refractive troubles, must be recruited from civilian life, as the needs for such specialized skill in the usual standing army of practically normal young men are minimal.

Early in the war it was found that the men who presented themselves as ophthalmologists were often either untrained or were so poorly trained that the establishment of a school for creating properly qualified men was essential to the competency of this particular service. Men thus prepared were placed under experienced ophthalmologists, the total number assigned to foreign service in the U. S. army having been two hundred and eighty, in striking contrast to the short-handedness of the eye service of the English army, which, although the best organized of the specialties in that army, included, according to Derby (*Annals of Ophthal.*, May, 1919), not more than thirty men actually engaged in eye work.

In the American Expeditionary Forces ophthalmologists were finally stationed in most of the front line hospitals (casualty clearing stations) so that every ocular wound should receive attention at the earliest possible moment, the principle having become generally recognized by the time of our entry into the war, that the golden opportunity in the treatment of traumatic corneal ulcers, penetrating and other wounds of the eye, as with all general wounds, lay between the moment of injury with its usual contamination, and the time when simple contamination flamed into active infection. Further it has long been an ophthalmic axiom that the earlier the removal of intraocular foreign bodies the greater the chances of ultimate vision, and placing of these skilled men behind the front, backed by base hospitals placed as far forward as possible and having radial control through their specialist chiefs, led, accordingly, to incalculable saving of vision and of life, as well as to the lessening of the final deformities in thousands of wounds.

Ophthalmologists, as members of the special units devoted to the surgery of the head, for the purpose of coordinating the work of the brain, eye, ear, nose, throat, and mouth surgeons, gave the most important aid in determining the location, extent and gravity of cerebral injuries and subsequent abscess formation. Fixed and mobile optical units were also attached to all of the larger armies subserving the ophthalmic services. Their functioning was made smoother by the early standardization of spectacle frames, of the size of the lenses, and by limiting the number of sphero-cylindrical combinations. These units were made necessary by the number of men with low vision, enrolled for limited service, whose vision was brought to the standard by glasses.

Derby (q. v.), in describing the general organization of the British Ophthalmic Service, states that the British had an eye center for each of their five armies and in the case of one army there were two centers. These were usually attached to a casualty clearing station and were manned by one ophthalmologist, occasionally by more. During quiet times he carried on his clinic and did a certain amount of refraction. He treated eye diseases and in general carried on the eye work for his part of the army area. He had a certain number of beds for emergency operations and for those cases where a few days in the hospital would enable a man to return to his unit. In active periods he did his best to cover the operative and consulting work of his area. But in times of stress most of the eye cases were sent down to the base except where the patient had other injuries and could not be evacuated. In very active times the pressure on the casualty clearing stations was so great that only the more urgent cases could be operated upon. There were many hospitals to be covered in the army area, with the result that a large part of the eye work in the front area was done by the general surgeon. Most of the eye cases uncomplicated by other wounds, were therefore quickly sent down to the base hospital, which in times of pressure acted as casualty clearing stations and evacuated cases quickly to England (home bases).

At the second line bases there were separate eye operating rooms, one hundred and thirty-two regular eye beds which could be increased at the expense of the other services if necessary, and an out-patient department which was exceedingly important and handled large numbers of cases. At these hospitals there were usually from three to six men doing the clinic and ward work. From the central eye hospital, the chief made periodic visits to the other base hospitals and was on call throughout the British Expeditionary Forces.

Each primary eye base had an optical unit attached to it which supplied the lenses prescribed in the areas served. These, in turn, were supplied by the great army spectacle depot organized in London. All told, there were not more than thirty men actually engaged in eye work. Much of this was of the same type as civilian work and these experiences were shared in kind by the ophthalmologists of every combatant group.

Allen Greenwood in his authoritative account of the ophthalmic service in the American Expeditionary Force (*Amer. Jour. Ophthal.*, Aug. 1919, p. 564) discusses in detail the organization and evolution of that service and much of his excellent and comprehensive description follows:

"On numerous occasions during the past campaign there was a shortage of men capable of doing ophthalmologic work, due to several factors. Ophthalmologists were not attached to all of the early base hospitals which came over, and to none of the evacuation hospitals, but the need of them in the latter was so urgent that the Chief Surgeon, at the suggestion of the senior consultant, cabled the request that a skilled ophthalmic surgeon be attached to all future evacuation hospitals to be sent over. For all the mobile hospitals that were organized in France and the early evacuation hospitals, there were not enough casual ophthalmologists from home at first available. The need for a very considerable number of ophthalmologists in the expeditionary force is, therefore, evident; and it is not probable that the supply of fully capable men will ever reach the demand. Therefore, the available men must be placed where they will do the most good.

"At the time the armistice was signed there were places where at least 150 ophthalmologists could be used to advantage in replacement divisions, mobile, evacuation, base and camp hospitals.

"1. *Divisions.*—Certain of the divisions serving at the front have had an ophthalmologist on duty and have received the equipment necessary for refractive work, the treatment of disease conditions and for minor operations. Certain other divisions have asked that an ophthalmologist be assigned. If there were forty divisions in France at the close of hostilities, with more to come during the succeeding year, it is easy to see what a drain on the ophthalmologic forces it would be to put a man in each division. No eye surgery should be done in the field hospital. At the most, only minor cases, or mild gassed eyes, should be held there; and these may be treated by the medical officers on duty, following the instructions from the ophthalmic division. If, in an emergency, the advice of an eye surgeon is required, it is always possible to obtain one from the nearest mobile or evacuation hospital. Eye patients from the divisions who need treatment should be sent to the nearest mobile, evacuation or base hospital. Refraction work for the division should be done in the evacuation hospital or a nearby base hospital.

"An exception to this is the replacement divisions. To each of these an ophthalmologist should be attached.

"2. *Mobile hospitals.*—An ophthalmologist should be stationed in every mobile hospital, and it has been the aim of the senior consultant in ophthalmology to accomplish this.

"At the time of the Argonne campaign, five of the mobile hospitals functioning had men capable of doing the best type of eye surgery.

"Mobile hospitals should be thoroughly equipped to do eye surgery. They should be provided with the Army eye case of 1917, the auxiliary eye case, an electric ophthalmoscope, condensing lens, an electric flashlight and a large and small eye magnet, which, in these hospitals, can obtain current from the roentgen-ray circuit. While the actual number of eye cases will be small, the availability of skilled eye treatment may make the difference between sight and blindness.

"In open warfare the number of eye wounds runs from 2 to 4 per cent. The ophthalmologist is a necessity in the mobile hospital, for experience has shown that only the exceptional general surgeon is sufficiently conversant with eye work. The ordinary debridement of wounds as practised in war surgery is absolutely contraindicated in wounds of the ocular structures. The retention of all possible tissue in the neighborhood of the eye is necessary for its integrity. Enucleations and eviscerations of the globe are seldom properly done by the general surgeon and packing of the orbit with gauze, so commonly done by them, is absolutely unnecessary and pernicious. The extraction of magnetic intraocular foreign bodies and the decision as to the course of treatment to be pursued in the case of an injured eyeball are matters for the skill of the specialist. These functions have been carried out by the men attached to evacuation and mobile hospitals.

"It is fully recognized that there is not sufficient eye work to occupy the whole time of an ophthalmologist in the *mobile hospital* or even in the evacuation hospital (except in peace time, when there is refraction to be done). He should be and, in many instances, has been placed as the second member of an operating team. All eye cases are referred to this team, and when it is necessary to perform an eye operation the position of the members of the team is reversed.

"During all times the ophthalmologist may be and is often assigned to other duties. It is a basic principle that all eye men attached to mobile and evacuation hospitals shall be prepared to undertake these other duties besides their eye work. During periods of stress, however, commanding officers of hospitals should not overload their specialists with so much work that they cannot attend to their special cases.

"Mobile hospitals need not be equipped to do refraction.

"3. *Evacuation hospitals.*—What applies to the mobile hospital applies also to the evacuation hospital. This latter unit, however, being of a more permanent character, should be equipped to handle all varieties of eye work. In addition to the equipment necessary to the mobile hospital, the evacuation hospital should have a trial case and necessary charts and a hand perimeter. Refraction for the divisions should be carried out here.

"During periods of stress, the ophthalmologist should be assigned as second man on a surgical team, and during peace times he should be able to devote the whole of his time to his eye cases.

"Where two or three evacuation hospitals are situated in close proximity, only one need be fitted up to care for refraction work and the eye men attached may pool their outpatient work.

"At the close of hostilities nearly every evacuation hospital in the field had an ophthalmologist attached, and, with the exception of eye magnets, had a fair, though hardly sufficient, equipment.

"A competent ophthalmologist was, for a time, stationed at the principal gas hospital; and plans were made to cover the other gas hospitals from the evacuation hospitals in the neighborhood.

"In periods of stress last summer and autumn the ophthalmic consultants from the headquarters at Neufchateau served at evacuation and mobile hospitals, as the supply of ophthalmologists was inadequate.

"4. *Base hospitals.*—Each isolated base hospital should have an ophthalmologist attached, and this has been the case, except for a brief period in a few instances. Each one should also have the complete ophthalmic equipment listed for base hospitals.

"The isolated base hospitals have taken care of all varieties of eye cases, except in some instances the magnet cases.

"Base Hospitals 15 and 17 and Camp Hospital 27 have each an optical unit. In other instances prescriptions for glasses have been sent to the nearest unit, or to Paris.

"Where the amount of work justified it in isolated base hospitals, the eye service was separated from the ear, nose and throat. Where the work was light, the two services have been united.

"5. *Base hospital centers.*—Where base hospitals are close together, in groups of two or more, one of the hospitals should be selected as a center to receive all the eye cases sent to the group. All of the ophthalmic surgeons necessary to such a central clinic should be provided from the surrounding hospitals. Two or three ophthalmic surgeons can easily take care of all the ophthalmic work of five or six hospitals so that a number of hospitals in the group need have no ophthalmic surgeon. Whatever consultation eye work is necessary can be handled by calling in one of the men from the central eye clinic. Where this plan has been adopted, and has been established long enough to be put on a firm working basis, it has proved of great value. It saves special equipment and personnel. It must be obvious to anyone that a single good sized eye clinic, similar in design to the one mentioned and appended in the body of this report, would be far better, for instance, in a group of ten hospitals than to have ten separate sets of clinical rooms. Each such center should have one of the most competent ophthalmologists obtainable in charge of the work, and he can act as consultant for the surrounding area.

"Dec. 1, 1918, the division of ophthalmology had eighty-six ophthalmologists listed as serving in base hospitals.

"6. *Camp hospitals.*—The amount of eye service required in camp hospitals varies enormously according to the function of the hospitals. Camp Hospital 26, which served the First depot division for several months, ran in the neighborhood of 1,000 new eye cases a month, occasionally more. At this camp hospital the eye, ear, nose and throat work constituted a single service and there was enough work for three and sometimes four men. There was no base hospital close to Camp Hospital 26.

"At some camp hospitals there was practically no eye work done and what little developed was transferred to the nearest base hospital.

"The policy of the division was to join with the ear, nose and throat service and place a combined eye, ear, nose and throat specialist at isolated camp hospitals. Camp hospitals in the neighborhood of base hospitals transfer their eye work to the base hospitals.

"Dec. 1, 1918, this division had listed twenty-eight men doing eye work in the camp hospitals. Doubtless there were a number more as all the camp hospitals had not been visited.

Routing of Eye Cases.

"The centralization of eye cases near the front seems to be feasible to a certain extent and is highly desirable. Such an experiment was carried out in the early part of the Argonne campaign, with a certain degree of success in spite of the fact that the hospital chosen to receive these cases (Mobile Hospital 6) was in an inaccessible location and a long distance back of the front. As the line moved forward, it became practically impossible to route cases there on account of the great distance and its inaccessibility.

"While this hospital was in operation, however, a very considerable number of eye injuries were treated there. An attempt was made to send to this hospital all cases with a head bandage.

"From the ophthalmologic standpoint the establishment of such a hospital simplifies the work of the division of ophthalmology and increases the efficiency of the service.

"A thoroughly experienced ophthalmologist may be spared for such a position. Special equipment may be placed at his disposal. Moreover, such a hospital is very useful for training less experienced men in the handling of eye conditions seen in war. Eye cases, therefore, when possible, should be routed to special front line hospitals.

"When eye cases are routed through to the base hospitals they should bear some distinguishing mark in order that they may reach the eye center in the area to which they are to go. To accomplish this purpose ordinary baggage tags, with a large EYE printed on them, were supplied to the front line hospitals and ophthalmologists were instructed to tag their cases before evacuating them. This system gave promise of being of considerable help in properly distributing cases.

Central Eye Hospital.

"After the organization of the ophthalmologic service a pressing need was felt for a base hospital that would have a large number of beds available for eye cases, where special equipment would be installed and which would be manned by a staff of experienced ophthalmologists.

"Base Hospital 115, equipped especially for head cases, ear, nose and throat, facio-maxillary and eye cases, was designated as this special hospital.

"A beginning had been made in routing to this hospital eye cases needing special observation and study and cases requiring extensive plastic reconstruction work. At this hospital were artists capable of making colored plates of especially interesting cases and a specially trained pathologist was also to be available. It was planned to send all eye pathologic specimens to this hospital for study and record.

Teaching and Observation.

"It has been fully realized that war ophthalmology presents certain special features, a knowledge of which is of great importance for the eye specialist if our wounded men are to receive the treatment which they deserve. Both the senior consultant and the assistant consultant had had a considerable period of service with the B. E. F. before serving with the A. E. F., and since then have had opportunities to see some of the work done by the French. The exigencies of the situation in France made it impossible to give many ophthalmologists opportunities for observation during the active period. Three men were sent for a period of time to observe in the principal British eye clinic, in France, and several more had an opportunity to see French work in various Paris hospitals. The others were instructed, as far as possible, by personal visits by the consultants and by means of circulars.

"Two other men had an opportunity to see some of the British and French work before the senior consultant was appointed.

"All of these men occupied important positions and their opportunities for observation in allied clinics were of considerable advantage to them.

"Base Hospital 115 was also to have served as the eye teaching center for the A. E. F., where men could be sent for instruction, especially during the less active winter months. It was also intended that the men sent there for instruction should be classified as to their qualifications as ophthalmic surgeons. This was done to a certain extent with casuals assigned to this hospital.

Suggestions for Improving Eye Service.

"1. *Refraction.*—A great deal of unnecessary refraction work overseas could be avoided if a more careful ocular examination were made at home, a more careful record made of vision and refraction, and if a permanent record were to accompany the soldier.

"The question of a permanent vision and refraction record was taken up by this office very early and a gummed record slip, similar to that used by the B. E. F., was printed and furnished with each pair of glasses.

"The best way to preserve this record is to paste it inside the cover of the pay book in the case of enlisted personnel, while with the officers and others, it may be pasted inside the glasses case, or better, carried with the personal papers.

"If this slip be fully made out a permanent record is preserved, and replacement glasses may be ordered without further examination.

"2. *Equipment.*—(1) Army eye instrument case. Certain changes can be made in the army eye instrument case, which would add to its usefulness:

"a. When the present supply is exhausted it would be wise to combine all necessary instruments in one case. Until that can be done changes in the contents of the 1917 case should be made, to make it more independent of the auxiliary case.

"b. The eye speculum now in the 1917 case might be replaced by a nonmagnetic one of a different type.

"c. Nonmagnetic forceps should be provided.

"d. A pair of more suitable enucleation scissors should be provided.

"(2) Auxiliary eye case. Certain changes should also be made in the auxiliary eye case, which would add to its usefulness:

"a. The present cautery set should be done away with; and a Todd cautery, or other cautery of that type, should be substituted.

"b. A Meller's speculum for excision of the lacrimal sac should be added.

"c. In an Army eye case a small supply of necessary special drugs in tabloid form should be placed. These should include atropin, homatropin, eserin, cocain and fluorescein. These would take up very little space.

"(3) Chest of eye equipment for base hospitals. It might be desirable to have standard chests capable of holding complete eye equipment for a base hospital. Such a chest should contain the following list:

"Army eye case, 1917—with changes as noted.

"Auxiliary eye case—with changes as noted: 1 flash light; 2 De Zeng electric ophthalmoscopes; 1 hand perimeter, with 6 dozen charts; 1 standard perimeter (for base hospitals only); 1 Zeiss, or Bausch and Lomb, binocular corneal loupe; 2 irrigators (New York Eye and Ear Infirmary type); 12 soft rubber ear syringes; 36 glass spheres (18, 20 and 22 mm.), 12 each; 1 set Jennings color vision test; 1 instrument rack; 1 complete set of test charts for distant and near vision; 4 different arrangements of letters; 1 illiterate chart; 1 reversed type chart; 1 chart beginning with a 20/100 letter; 3 frosted bulbs for retinoscopy and ophthalmoscopy; 1 extensible wall bracket for ophthalmoscope light; 12 prescription pads with carbon copy; 1 complete set of directions for vision testing and record keeping should be in every instrument case and trial lens set; 1 copy of Manual 3 and one copy of Manual of Ophthalmology (Surgeon General's Office); 2 eye magnets, one large and one small (Lancaster type), with electric foot switch and necessary connections should be furnished, but packed in separate box, on account of their weight.

"3. *Personnel.*—All ophthalmologists should be tried out and carefully graded in the United States before being sent on foreign duty; and their records should be sent over with them, or in advance of them.''

The French, Italians, and Germans have gone much beyond us in specializing their surgery, and their results are so admirably efficient that they further justify to the full the endeavor now being made in America to demand higher specialistic ability. The eye sections of the German field hospitals were exceptionally equipped from the start, carrying both Haab and Snell magnets, a perimeter, an X-ray apparatus for stereoscopic radiography, and a complete outfit of surgical and illumination instruments. In common with the developed service of the other combatants, consultation with general surgeons, internists, otologists, rhinologists, and dentists was obtainable at all times, an idealization of ''group medicine'' which will undoubtedly become increasingly popular in civilian practice throughout the world in time. The amazing complexity of many of the military wounds makes hand in hand work with other surgical specialists a constant necessity.

In the stressful periods of heavy fighting it is not unusual that considerable overlapping of the surgical specialties occurs, and not seldom eye work has been attempted by general surgeons, often to the serious detriment of the wounded men, mainly through the mistaken application to the eye and its adnexa of the general surgical principle of ''débridement,'' or gross excision of tissue which is presumably dead or contaminated, in and about the track of a projectile. Derby speaks of such cases where complete ''débridement'' of the eyelids had been performed, with horrible resulting deformities and confirms the observations of experienced ophthalmologists in all the armies who have witnessed scores of cases where fragments of shattered eyeballs of all sizes had been left untouched and buried under the conjunctival overgrowth to the active danger of the fellow eye, and who with almost equal frequency have seen needlessly coarse enucleations which were more nearly exenterations of the orbit, and in which marked sinking in of the upper lid, conjunctival bands, and more or less marked symblepharon made secondary plastic work and implantations necessary.

WAR WOUNDS AND INFECTIONS.

During the first two years of the war infection so nearly overwhelmed the medical service as to partake of the nature of a surgical disaster. Virulent gas, tetanic and pus infections were common, with a high mortality. Where it was impossible to get the patient to the surgeon within ten or twelve hours practically every wound in certain battle districts such as Flanders, was infected. The incidence of gas infection was appalling and the death rate was over fifty per cent. in these cases, among which are included the cases of local gaseous infection, which, if taken early are not really dangerous. The treatment of fractures was disastrous, usually being followed by amputation or death or both. Carrel (*Mil. Surgeon*, Apr. 1917, pp. 479-485) states that out of one hundred amputations done at this period seventy to eighty were performed on account of infection. At this time almost every battle casualty which reached a base hospital had been wounded several hours or days previously and was of the graver type, the soldiers lying with sunken eyes, their cheeks bearing the hectic flush of sepsis and their prostration intense. Before their injury many of these men had been more or less starved, partly dehydrated by prolonged deprivation of water, and, owing mainly to difficulties of transport, often had been chilled and mentally prostrated by lying out in the cold and wet in shell holes, exposed to intense shell fire and incapable of moving or of being moved until a favorable opportunity arose.

With the creation of advanced line surgical stations in which the shocked were restored, hemorrhage checked and transfusion and imperative surgery done, with rapid transportation of the wounded an accomplished fact, in spite of Sisyphean difficulties, and with the successful evolution of methods of primary and secondary sterilization of wounds, based upon thorough studies of the flora of wounds and the time needed to convert bacterial contamination into an active infection, the picture presented by the wounded changed to one of cheer and of early recovery.

The most valuable lessons taught by front-line treatment are, 1. That fatigue, climate, want of cleanliness, shock and hemorrhage, and especially the last two, predispose to wound infection; 2. That the value of the immediate surgical treatment of eye injuries, of tissue defects in their initial stages, of brain injuries, of abdominal and pulmonary, nervous and vascular wounds, of the great fleshy wounds, especially where complicating compound fractures as in the thigh and arms, and finally, and by no means least, of the immediate treatment of war neuroses, has been finally and fully proven and can no longer be considered controversial; 3. Skin deep disinfectants and first-aid dressings are impotent to mitigate in any way the infection forced into the wound by the projectile.

In general every war wound must be considered as potentially infected. Bullet wounds made at short range may remain sterile if they are not compound fractures, but a bullet wound made from a long range will be almost as badly torn as a wound made by a shell fragment. Most of the wounds, however, are made by pieces of exploded shell, which vary in size from several square inches to particles as small as a pin-head, all of which, because of their ragged nature, wherever they strike a part covered by clothing, take shreds of it into the wound. These shreds of clothing are the source of most prolific bacterial growth, while the tissue torn from its blood supply, and necrosing, furnishes the best of media. *The body of a trench dweller is inhabited by a varied and extensive bacterial flora so that unless the wound is dressed in less than six hours it will be infected from the skin. Wounds of the face are infected as easily as those of the body but because this tissue is highly vascular and these wounds are shallower and drain easily their infection is not usually of such desperate character.* Lawrence (*Military Surgeon*, Feb., '18), in a study of the aërobic bacteria, found in wounds received on the battle field of the Somme, that the time of the year, to a certain degree, determines the type of the infection, the pneumococcus, micrococcus catarrhalis and diphtheroid organisms appearing more often in wounds during winter than summer. The location of the battle field is also to be considered. In the lowlands of France the tetanus bacillus and the bacillus Welchii are almost universally present in the manurial earth. On the mountains there are no cases of gas infection, while in the adjacent Alpine valleys the surgeons of the Italian armies found it quite common.

The great mass of infecting organisms are micrococci and bacilli of the colon-proteus group. In more than 80 per cent. of the wounds studied culturally on the Somme streptococci were found and these flourished in the deeply pocketed wounds, but in the shallow wounds or in the deep wounds made shallow by wide opening they were replaced by staphylococci in the course of healing. After the introduction of the Carrel procedure smears made from each wound every third day for the purpose of counting the organisms show that micrococci in the form of streptococci, staphylococci and diplococci are always present in abundance in contaminated wounds. Bacilli, usually of the typhoid-colon size and Gram-negative, were present in ninety-five per cent. of the Somme wounds and bacillus coli found in more than fifty per cent. of these wounds. The streptococci and Gram-negative bacilli disappear under irrigation in a shorter or longer time depending upon the accessibility of all the pockets to irrigation. If the wound is imperfectly irrigated, the persistence of aërobes in the exudate indicates an unirrigated discharging sinus or a hidden foreign body and contraindicates closure of the wound, while when the bacterial contamination has become reduced to a very occasional Gram-positive coccus or diplococcus, their presence is ignored by the plastic surgeon and the wounds are treated and considered as bacteriologically sterile.

Two great surgical innovations were successfully developed to combat infection: Débridement (first proposed, according to Bottomley, by Col. Gale of the British Expeditionary Force and popularized by Lemaitre) by the excision of all devitalized tissue, all foreign material and all denuded bone, permits the successful "primary closure" of contaminated wounds. Its application to wounds of the face i however, indicated only in the presence of a developing infection and its unwise practice here as a routine measure on these shallow and relatively highly vascular tissues has led, in the hands of general surgeons, to irretrievable tissue defect and hideous scarring. The necessity of saving every possible fragment of tissue in wounds of the eyes and orbits cannot be too strongly emphasized. The free blood supply and the shallowness of the tissues of the lids and orbits and their immediate surroundings, and the fact that facial wounds are generally so superficial and broad that their depths are easily accessible to irrigation, explains both the comparative freedom of this part of the body from tetanus and gas infections as well as the happy results of treatment more conservative than débridement. The practice of this method in wounds of the skull, however, as well as in the fleshy parts of the body has been an immense factor in the later prevention of serious infection.

The Carrel-Dakin method, which has come to be the method of election in the treatment of war wounds, although its exact place in civil surgery is still difficult to define, has as its foundation the recognition that little or no bacterial growth occurs in projectile wounds during the first four to six hours following injury. Such growth as does occur comes mainly from implantation of organisms with the projectile or secondary missiles and where these wounds can be effectually opened and cleansed of foreign material and devitalized tissue before bacterial growth extends to and into the surrounding tissue, infection does not occur or is of a negligible type. Where prompt surgical attention has been impossible and infection has spread throughout the wound and its remote pockets, this treatment further recognizes that each pocket must be freely opened, all foreign bodies removed and small rubber tubes inserted into every recess. By this means 0.5 per cent. solution of sodium hypochlorite without alkali is brought into contact with every part of the wound by two-hourly flushings which are continued until all microbes have disappeared from the wound. This requires about forty-eight hours for a surface wound and six to ten days for other wounds. Bacteriologic examinations are made every two to three days, as the clinical appearance is no criterion of the degree of sterilization. When both clinical and bacterial examinations show a sterile wound the edges are brought together by adhesive plaster or stitches and union takes place in a few days. As a result, although ninety per cent. of the wounds are still shown to be contaminated and almost every wound suppurates, the infection is less dangerous and the death rate decreased in great measure.

Carrel states that if new and better methods of treatment are used in conjunction with rapid transportation of the wounded and good organization and equipment of the hospitals, important progress can be made. By using the proper technic, wound infection can be almost entirely controlled and pus can be eliminated completely from the hospitals.

Depage, in whose hands this standard technic has reached the highest development gives the details surrounding its application (*Jour. A. M. A.*, July 19, 1919) which are sufficiently important to reproduce here:

"On admission of the patient, the injured region is shaved, and then washed with a neutral solution of sodium oleate. Débridement and épluchage of the wound are practiced immediately thereafter. At the same time the Carrel tubes are introduced to the bottom of the wound so as to permit the irrigation of the entire wound surface. To the entire surroundings of the wound are applied compresses smeared with petrolatum in order to prevent irritation of the skin. The wound is dressed with compresses of absorbent material. After the return of the patient to bed, the Carrel tubes are connected with the receptacle containing the surgical solution of chlorinated soda, and irrigation is carried on every two hours, controlled by a simple pressure forceps of Mohr. The dressings are renewed every day, careful lavage of the wound being made with sodium oleate. One must not allow the slightest concretion to remain on the skin about the wound lest colonies of microbes be hidden. We were not able, however, to derive from the Carrel method all its benefits until we made a regular determination of the abundance of the micro-organisms in the wound exudates. This bacteriologic control was repeated in the same wound every two days, and tracings were made of the microbic strength. Infected wounds were rendered sterile by the Carrel treatment in from six to eight days. Bacteriologic evolutions in a wound may be considered under the three periods of acute infection, attenuated infection and sterilization. These periods correspond to three periods in the organic reaction of tissues. In deciding the moment of suture we have recognized that: (1) wounds slightly infected by ordinary microbes may be sutured with every chance of success; (2) the presence of staphylococci does not contraindicate suture; (3) the perfringens organism remains enclosed in the wounds only a very short time, but until these microbes disappear it is dangerous to suture; (4) a wound should not be sutured in the presence of even a slight streptococci infection.

"To determine better the moment most favorable for suture, we have supplemented the counting of the microbes on the smears subjected to bacteriologic examination by cultures instituted regularly after débridement and before the suture, and conclude that: (a) For wounds feebly infected from the first day with ordinary microbes we may proceed to suture when at the second examination the smear yields only one microbe in a visual field. (b) For wounds strongly infected by ordinary microbes, we may resort to suture from the moment the curve comes down to one microbe in four fields. (c) For streptococci infection we should never suture, but submit the wound to adequate treatment, preferably that of Carrel, and wait until the streptococci have disappeared, or become sufficiently attenuated to permit primary union. Streptococci vaccination may here render the greatest service. Immediate primary suture may be made immediately after débridement or from two to four days after débridement. Delayed primary suture or early secondary suture is done without refreshing wound surfaces, by simply approximating them. The suture may be made in the course of the granulation of the wound when sterilization is assured. Secondary suture always necessitates the refreshing of the wound surfaces. The objective toward which we direct the surgical treatment of open fractures, apart from the orthopedic treatment, is the transformation of an open fracture into a closed fracture. In joint wounds our results show the superiority of immediate suture after wide arthrotomy, closing of the joint cavity, over any other method of treatment. In wounds of the elbow and shoulder, however, the Carrel treatment followed by secondary suture or by cicatrization by second intention is evidently indicated."

As to whether débridement or the Carrel-Dakin technic should be applied to a given case, the end results would seem to be identical, provided that the wound is mechanically cleaned. But in view of the inevitable great differences in skill and in the thoroughness of mechanical cleansing of wounds shown by military surgeons in general, it would appear safer to have a standard technic, with open treatment by the Carrel method and with secondary suture done under bacteriological control.

Of the characteristic forms of unusual infections which have involved the eyes, the most virulent and dramatic have been 1. Gas bacillus infection, and 2. Tetanus, while 3. Metastatic or endogenous infection from suppurative processes elsewhere in the body has been rare; 4. Exogenous infection due to perforating injuries formed the bulk of oculo-orbital infections.

Gas Bacillus Infection.

Gas bacillus infection has been compared to typhoid fever in former wars in the extent of its devastations. It is known to exist on every battlefield but more particularly on those which have repeatedly been fought over and where the successive enrichments of the soil in trench warfare have so increased the virulence and infectivity of its manurial bacterial flora as to give the disease at times almost the character of an epidemic.

As the likelihood of infection varies directly with the amount of extraneous material which may be carried into a wound, it is clear that shell-fragment wounds are most often the seat of this form of infection, shrapnel wounds next and bullet wounds the least. Gas gangrene is most common in the fleshy parts of the body, affecting the buttock, thigh, leg, trunk, shoulder, arm, forearm and neck in about that order and being seldom seen in hand and facial wounds. The rich blood supply of the face and orbit, the fact that dirty clothing is not carried into the wounds, the shallowness and breadth of facial wounds and their accessibility to free irrigation and effective treatment are undoubtedly the main protective factors of this region, wounds of which, if not opening into the nasal cavities, may accordingly be closed, with drainage.

"Gas bacillus infection can, of course, occur in any wound; but it is almost invariably in severe wounds that it does occur, and particularly in those of the lower extremity, associated with fracture, vascular injury and muscle damage. Such a wound is always far larger beneath than in the skin, and of surprising irregularity. Its depths hide one or more rough missiles and bits of clothing or equipment. Its crevices are filled with blood clots, large and small, and it is walled by muscle, fascia and aponeurosis, shockingly torn, contused and loaded with indriven fragments of comminuted bone and with extravasated blood.

"The regional blood supply is locally or massively interfered with by pressure obliteration, or by tearing of the vessels with thrombosis.

"Even if it is sterile, such a wound presents many dangers and difficulties. But added to devitalized tissue and blood clot we have infection, usually with a varied flora, particularly the gasogenic, saprophytic anërobes. No matter what variety of anërobic saprophytic it may be, here we have all the conditions necessary for its rapid and successful growth: warmth, moisture, darkness, abundance of suitable nourishment and a minimum of oxygen admissible from air or blood supply." As Van Beuren (*J. A. M. A.*, July 26, 1919, p. 239) further remarks, "It is no wonder that the gas infection runs up within a damaged muscle sheath like the flame up a flue, and follows the vessel sheaths and blood-filled intermuscular spaces as a river follows its banks."

The pathogenesis of gas gangrene is exceedingly complex as it is caused by a great variety of organisms, according to Weinberg and Seguin (*La Gangrène gazeuse, Bactériologie, Reproduction expérimentale, Sérothérapie*, Paris, 1918) some of which play a more dominant part than others, forcing a classification into principal and accessory germs. They consider that the following anërobic germs cause gaseous infections: B. perfringes (Welchii), B. edematiens, Vib. septique, B. fallax, B. aërofœtidus, B. sporogenes and possibly two aërobes, B. coli and B. proteus, and that a gaseous infection is more often the result of a combination of principal and accessory germs.

There are cases where the emphysematous prevails over the edematous lesions, produced by virulent germs which are great gas producers and which give rise to the classical emphysematous forms; cases in which edemata prevail and gaseous infiltrations are slight or even absent; these are caused by toxic anërobes and constitute the toxic or edematous forms: and where gaseous and edematous signs exist together several forms of anërobes coexist.

Not less than 40 different types of anërobes have been recognized by Weinberg and Seguin.

The signs which indicate a beginning gas infection are a dirty, sloughing appearance of the wound, from which a dirty serous exudate escapes, together with occasional bubbles of gas. Crepitation is felt under the skin and the discharge has a fecal-like odor; the adjacent tissues are reddened as in cellulitis and are edematous and tender. The toxemia is out of all proportion to the apparent severity of the wound. The skin is cold, pale and clammy; the pulse weak and rapid, the temperature rises steadily and death supervenes. In local gas edema the infection starts about the infecting object as a rule, progressive phlegmon, death of tissue and toxemia following each other slowly or rapidly in hours or days and making wide opening of the wounds imperative at the appearance of the first signs. Devitalized and necrotic tissue should be excised as thoroughly and freely as can possibly be done, until a tissue base is reached which is of normal color and bleeds freely. The greatest pains must be taken to remove all loose bone, foreign bodies and blood clot. As much skin may be left in the débridement as one dares. The Carrel-Dakin solution, used with precise technic, is very generally agreed upon as the best post-operative treatment, combined with the use either of a polyvalent or pooled serum of the three common infecting agents, B. perfringens (Welchii), Vibrion septique, and B. edematiens, or, where early bacteriologic examination has identified the infecting agent, a specific antiserum is preferably used in the form of intravenous injection combined with deep muscular injection in the vicinity of the wound. In regions where gas edema and gangrene occurs with unusual frequency, preventive injections of from 20 to 100 cc. of pooled serum are given as early as possible after the demonstration of gasogenic organisms in the wound, and repeatedly, if symptoms develop. For curative purposes, however, the doses are increased, to 80 to 100 cc., which may be repeated after six hours and again in twenty-four hours, followed by daily smaller injections. According to Van Beuren (q. v.) Dr. Elser advises the following routine for the serum treatment:

1. A prophylactic dose of polyvalent serum, given as early as possible after the receipt of the wound, combined with tetanus antitoxin.
2. Bacteriologic examination of the wound and establishment of the presence of gas bacillus infection and determination of the variety of the bacteria. The determination can be made in about twenty-four hours.
3. Administration of specific serum, either single or polyvalent or "pooled," according as there are one or more gas formers found, and also antistreptococcus serum.

It is emphasized that serotherapy is entirely auxiliary and in no way replaces operative treatment of the wounds. Quénu, for example, in advocating the use of Leclainche and Vallée polyvalent serum, declares that "the mechanical early and complete clearance of the wound is essential to success;" while Rouvillois and others, using antivibrion septique and antibellonensis serum, "practice the surgical technic exactly as if there were no question of serotherapy." And Marquis concludes that, "although curative serotherapy assures recovery in the great majority of cases, it is only an aid to the necessary surgery."

As to the results of preventive and curative serotherapy, in November, 1917, the third Interallied Surgical Congress for the Study of War Wounds reported that antiperfringens serum seemed to have given favorable results as a preventive injection, and that the antivibrion septique and antiedematicus serum had given very appreciable results, both from a preventive and a curative standpoint. In November, 1918, the same conservative body announced that preventive serotherapy in the French Army had reduced the frequency of gas gangrene, and that curative serotherapy had given equally encouraging results. But they added that these should never be regarded as more than an adjuvant to surgery which, as they put it, "is still indicated and in no way modified." The specificity of antibodies, of course complicates the problem. It is like a lock which can be opened only by one key, and consequently the administration of the serum in its preventive and its curative uses must be governed accordingly.

Cases of penetrating wounds of the orbit, while relatively rare, have been seen by many observers, although, as such cases are mainly of the severe cranio-cerebral type, involving the orbito-nasal region and with exposure and extrusion of the brain through breaches in the anterior fossal and frontal bones they have been under general surgical rather than ophthalmic care. Several such cases are reported by Cushing (*Brit. Jour. of Surgery,* April, 1918) by Greenwood (*Medical War Manual* No. 3), who reports penetrating wounds of the orbit with subsequent gas bacillus infection. James (*Ophthalmic Review,* Vol. XXIX, p. 161) reports his second case of gaseous panophthalmitis of non-military origin giving the references to date. Pringle (*Brit. Jour. Ophthal.*, March, 1919, p. 110) reports three unique cases of gas infection of the cornea following gunshot wounds of the eye. The second case, seen three days after the face and eyes had been wounded by a detonator explosion, showed multiple septic wounds of the face and vision reduced to light perception in the right eye, while the left was blind. The right eye was congested and dirty with muco-purulent discharge from the conjunctiva. Superficial wounds of the nasal side of the cornea existed, soiled by dirt. No evidence of perforation. Fundus and media normal. The left eye was intensely inflamed, the secretion was muco-purulent and at the nasal margin of the limbus an infiltrated perforating wound was apparent. About five hours after the first examination the whole left cornea had become infiltrated, soft and swollen and was bulging forward at the wound; while chemosis of the bulbar conjunctiva had set in with a decided increase in the general inflammation. The eye was enucleated by Lister's method and the cavity freely irrigated with 1-5000 bichloride of mercury solution. Recovery was uneventful and on discharge 5 days later, vision of 6/18 had returned to the remaining eye. Bacteriological examination of portions of the cornea and globe showed staphylococci and a gas-forming bacillus which was not identified.

Nine months after the first another case was seen and is reported in detail.

Apparently there is little to choose, from the standpoint of risk of generalizing infection, between evisceration and enucleation by Lister's method in these cases of gaseous panophthalmitis, save that the presumptive ease of treatment of infected orbital fat and its musculo-aponeurotic content is vastly greater by the continuous irrigation in the absence of the globe.

Gas and tetanus bacilli have the common characteristic that their peculiar, abnormal manifestations fail to appear in a large number of cases in which their presence in the wound has been demonstrated. In seeking an explanation of this Bulloch and Cramer (*Proc. Roy. Soc.*, London, May 15, 1919) found that emulsions of earth were the only ones which frequently, though not invariably, elicited gas gangrene or tetanus when injected with the corresponding bacteria which had been detoxicated by washing. As filtered watery extracts of earth were also effective and as the power for damage differed in samples obtained from different localities, these authors conclude that the chemical contamination of wounds, as well as their bacterial invaders, may play a part in determining the appearance of these infections. Another common characteristic of gas and tetanus bacilli, and of many other pathogenic organisms as well, is that they may lie latent in a wound which has been thoroughly healed and may later be liberated and multiply, as a result of the traumatism of the surrounding tissues or by operative procedure, showing all the evidence of an acute typical infection. Pybus and his associates have demonstrated (*B. M. J.*, Apr. 19, 1919) this latency by examining missiles which were apparently sterile and which were extracted from the tissues from 1 to 30 months after injury because they caused pressure on nerves or interfered with motion. Fifty per cent. of 44 specimens examined bacteriologically were sterile. Staphylococci were demonstrated in 10 cases, putrefactive bacilli in six, tetanus in two and gas bacilli in one. In a case where a fragment of shell was removed streptococci and tetanus were found. Suppuration resulted and antitetanic serum was injected at once, with complete recovery.

Tetanus.

The control and practical banishment of tetanus by virtue of the preventive quality of its specific antitoxin along with thorough removal of foreign matter and devitalized tissue is one of the triumphs of preventive medicine in this late war, especially in view of its incidence and gravity during the earlier months. Like gas bacillus infection, its relation to wounds of the eyes is mainly in connection with the grosser orbital lesions with extensive tissue defects and craniocerebral involvement. R. Goetz (*Clin. Ophtal.*, vii, 4) records fifty cases of tetanus following orbito-ocular injuries especially where the wounds were soiled by richly manured earth. The points of entrance for the organism were the cornea, sclera and limbus, the orbit, brows, lids, and very rarely the conjunctiva. That tetanus with fatal results may follow a penetrating injury limited to the eyeball, is, of course, recognized in civil injuries, a case to the point having been reported by Sattler (*Arch. Opth.*, Jan., 1918, p. 64).

A case of tetanus following ocular injuries by a whip-lash is reported in the *Ann. d'Ocul.*, cliii, 9, along with 19 other cases of tetanus following injuries to the globe. The injury caused a perforation of the cornea with iris prolapse. When seen three weeks later panophthalmitis had begun and tetanus had set in leading to death in three days. There were characteristic symptoms of cephalic tetanus on admission, with trismus, difficulty of deglutition and paralysis of the seventh nerve.

Among the anomalous forms of tetanus there are two particular groups whose manifestations are confined to the head; in the first the eye muscles are involved in more or less complete ophthalmoplegia, and in the second, the facial, hypoglossal or other cranial nerves may be implicated, in focal processes comparable to those localized forms of tetanus which appear in the limbs as monoplegia or paralegia, or which involve the muscles of the trunk alone. Courtois-Suffit and Giroux (*Les Formes Anormales du Tetanos,* Paris, 1916) discuss these eccentric forms in considerable detail. It is now quite generally recognized that the atypical forms of tetanus occur as the result of incomplete and partial immunization with antitetanic serum in the same way that attenuated typhoid may follow insufficient serotherapy. Osler warns, however, that every muscle spasm following a wound is not tetanus, as functional spasm, neurosis, and possibly reflex spasm associated with wounds, as described by Babinski, may be the source of the muscular over-action, while early in the war, Mills (*Jour. Amer. Med. Assoc.*, Oct., 23, 1915) called attention to the simulation of trismic spasm produced by fractures of the lower jaw with remote points of entrance of the missile. Lagarde (*Military Surg.*, Feb., 1917, p. 218), whose summary of the position of tetanus therapy to date has been freely drawn upon here, states that there seems to be strong experimental evidence that the immunity given by a primary injection of antitoxin is lost in about ten days, for which reason it is considered advisable to give a second subcutaneous injection in all septic wounds at the end of seven days; and further, in wounds following a chronic course, caused by shell fragments or bombs, a third or fourth injection should be given at intervals of seven days. The danger of anaphylactic shock is said to be negligible when prophylactic doses of 500 U. S. A. units, contained in 3 cm. of horse-serum are given subcutaneously, whatever the interval after the preceding injection. The primary dose, 500 such units, is given at the dressing station. A prophylactic injection should be given invariably before operation, best as 500 units intramuscularly, two days before operation. This should be done, even if the wound is healed, unless a previous dose has been administered within seven days. It takes forty-eight hours for the antitoxin to be absorbed when administered subcutaneously and twelve hours with intramuscular injection. Anërobes like tetanus bacilli which are saprophytic in habit may live dormant without propagating in clean wounds for two or three months. Hence the reason for the precautionary prophylactic dosage.

Montais (*Ann. de L'Institut Pasteur,* T. xxx, 1916, July, No. 7) distinguishes four degrees of tetanus: (1) The tetanus which remains localized in the region of the wound, the pontine and bulbar centers escaping altogether. This is, strictly speaking, local tetanus, and it occurs almost entirely within the first month after the prophylactic dosage. The incubation may be only a few days but in one case was three months. Only two of the reported twenty-one cases cited. (2) The second group, more frequently seen than the first, though its onset is local, gives evidence that the higher centers are not completely protected, because after the lapse of days or weeks, trismus and other general symptoms appear, more often of no great severity. The mortality is naturally higher than in the first group. (3) In the third group the onset is usually from the second month onward: the protection of the higher centers is much less: trismus, cervical rigidity, and others of the well-known general symptoms are noted. The local onset in the injured member is no longer seen or at least is no longer sufficiently present to attract attention. The crises are not so severe as found in one entirely unprotected, and the spasticity shows a tendency to persist. The mortality is from 33-50 per cent. (4) In this group there is no evidence of protective immunity and the tetanus is of the ordinary type. Montais tells us that the tetanus organism is found in wounds usually in the form of spores which may germinate, liberating toxins up to many months after implantation and long after the effects of the prophylaxis have disappeared. Hence, unless protection is kept up as recommended the protection afforded by the antitoxin gradually wears away, trismus and other general symptoms appear and the disease runs its ordinary course.

The classical symptoms of tetanus such as trismus, risus sardonicus, opisthotonos, etc., are very seldom seen in those treated by prophylactic injections, but when trismus appears, the case is usually fatal. The importance of early diagnosis is extreme as all clinical and experimental evidence shows that successful treatment diminishes rapidly with the length of time after the first symptoms have been observed. Among the earliest symptoms are spasticity and increased reflex excitability of the muscles near the wound. In these cases the toxin reaches the spinal cord primarily by the nerves which are connected with the seat of injury and therefore the motor nerve cells which govern the muscles about the wound will be the first affected. Spasticity and rigidity may precede the other symptoms of tetanus by many hours. For this reason, the assistants and dressers are enjoined to report the first occurrence of rigidity, twitching, or local increased reflexes which may be provoked in response to gentle tapping or pressure. Other early symptoms of diagnostic value may be "anxious look," pain in back of neck, sore throat, general restlessness, unreasonable outbursts of temper, insomnia, violent headaches, excessive yawning, complaints of spasm in the limb injured, stiff neck, difficulty in swallowing without recognizable cause, stitch in side, profuse local or general sweats, and difficulty in micturition.

After symptoms have begun intrathecal injections of antitoxin must be given as soon as possible after the first symptom has been noted, an hour's delay often meaning the difference between success and failure.

In extreme cases massive doses of serum are urged, without giving too great importance to anaphylactic accidents, it being sounder practice to give an unnecessary injection, either under these conditions prophylactically, or in delayed operative work, than to allow the development of tetanus needlessly. Treatment by magnesium sulphate and phenol has been put aside as useless or impractical.

Metastatic Ophthalmitis.

It is worthy of attention that the very small number of cases of this condition reported in detail, occurred mainly during that period of the war when wounds were literally pools of suppuration and the wonder is that this "panophthalmitis of pyemia" was not a more frequent complication. Probably such relative immunity of the eyes may be explained by the work of Rosenau, Irons, Brown and others, dealing with specificity in the strains of germs, notably streptococci, in their attack upon specific organs, the usual pyemic strains, for example, probably lacking specificity with regard to the eye. There certainly seems to be no ground for assuming a resistance to infection inherent to the eyes.

Piehler (*Klin. Monatsbl. f. Augenheilk.*, June, 1915, p. 682) records three cases, all of them ending fatally, in which sudden dilatation of the pupil and loss of reaction to light was followed in from one to three days by characteristic metastatic ophthalmitis. The causative conditions were pneumonia, pyemia, and meningitis complicated with pneumonia.

In his *Atlas der Kriegsaugenheilkunde,* 1916, von Szily gives the details of four cases: Case 1. A soldier was wounded by a rifle bullet which penetrated behind the right ear into the mouth destroying the superior maxilla without injuring the eyes either directly or indirectly. There was also a severe wound of the buttock. Twenty-eight days later exophthalmos of the right eye was noted, with chemosis, haziness of the aqueous, iritis and loss of the fundus reflex. The left eye was similarly but less involved. The process was progressive and within nine days panophthalmitis was fully developed. Death occurred 41 days after injury.

The post-mortem examination showed pneumonia, pleurisy, pericarditis, septic infarcts in the spleen and kidneys. Pneumococci were recovered from the vitreous and from all the viscera.

Case 2. A fragment of shell-casing had produced a carotid aneurysm in the left side of the neck. This was operated upon nine weeks after the injury but, because of persisting temperature, the wound was reopened ten weeks later. An unsuccessful attempt was made to remove the fragment which was lodged in the cervical vertebræ, followed about a month later by progressive inflammation of the left eye with exophthalmus, chemosis and finally by iritis, panophthalmitis and enucleation. Streptococci were recovered from the vitreous. The eye showed a complete detachment of the retina, with a generalized intraocular inflammation.

Case 3. Was wounded in the right thigh by a fragment of shell-casing, gas gangrene developing and making amputation necessary. Despite this a general pyemia developed with involvement of the left eye in a metastatic process two weeks after the injury. From the vitreous of the enucleated eye staphylocci were recovered, as well as from the blood. Death resulted four months later, and at autopsy purulent metastatic lobular pneumonia of the left lung, septic endocarditis and generalized septic inflammation of both eyes were demonstrated, the retina yielding a Gram-positive coccus.

Case 4. Received multiple wounds of a leg, one of them a compound fracture of the tibia. About three weeks later ciliary injection appeared in the left eye followed by the appearance of a cloudy vitreous, iritis and panophthalmitis, forcing enucleation. The vitreous contained typical chain cocci. At the autopsy the pathological findings were cellulitis of the leg, with a septic thrombus in the femoral vein; metastatic abscesses in the rectus muscle, epididymis and endocarditis. v. Szily believes that in this case the infection came through the ciliary vessels of the iris and ciliary body, and in the others through the retinal vessels.

Coria and Boulat (*Arch. d'Ophtal.*, May-June, 1918) report a case of bilateral metastatic infection following deep shell wounds of the left buttock, with lodgment. This wound was suppurating but the patient was able to walk about with relative comfort. About 3 months after injury the fragment of shell was removed with some carious bone and on the following day severe pain appeared along the course of the sciatic nerve and the temperature rose. Eight days later complaint was made of pain on motion in several joints indicating a spreading infection through circulatory channels. Seventeen days after this a slight conjunctival reaction was noted, becoming more severe. A month later the pupil had become dilated, immobile and vision was dim. From this time the signs of acute panophthalmitis developed rapidly in both eyes and ultimately perforation of both corneæ occurred and death ensued. No autopsy was obtained.

Löwenstein (*Med. Klinik*, 1918, No. 41, p. 1017) and Wilmsen (*ibid*) report cases of bilateral metastatic ophthalmitis, while Derby (*Am. Jour. Ophthal.*, May, 1919) speaks without detail of metastatic infections of the eye and orbit all from infected compound fractures of the femur.

In all of the reported military cases, as in those seen in civil practice, the intraocular infection appears after long-continued suppuration elsewhere in the body and the parallel goes further in that bilateral ocular metastases invariably end fatally.

Lawford, reviewing the subject in the *B. J. O.*, Jan., 1919, refers to the interesting group of 46 cases collected by Chenet, in which the ocular signs appeared from one to forty days after the injury. It is commonly noted that the onset of ocular infection is a signal or index that general bodily resistance to infection has weakened, in that thereafter the pyemia invariably makes dramatic headway, and Chenet would seem to have well expressed a clinical truth in his remark that "ophthalmitis is a true sign of the defeat of the human organism, which has been maintaining for a long period a struggle against invasion by pyogenic microbes, derived from the infected wound.'' In Chenet's series the 22 examples of bilateral involvement all ended fatally, death occurring from the first to the fourteenth day after the appearance of ocular signs.

Lister (*Lancet*, July 20, 1918) points out the difference in the clinical picture according to whether the anterior or posterior vessels receive the septic embolus, in the former, exudate appearing early in the anterior chamber and anterior portion of the vitreous, together with marked discoloration of the iris; in the latter form, where the primary infection is through the choroidal or retinal vessels there is bulbar chemosis, loss of fundus reflex and dimness of vision without iridic discoloration or exudation into the anterior part of the eye, at least in the early stages. Within 24 hours there is slight proptosis and loss of vision becomes complete.

Exogenous Infections.

The exogenous ocular infections are the common residues of the numerous penetrating wounds of the eyes, as well as the not infrequent complications of traumatic corneal ulcerations, so common in military life. They occur in both acute and chronic forms with frequent borderline types.

The acute form, usually streptococcic or pneumococcic in origin, and usually expressed as a rapidly progressive irido-cyclitis with its characteristic signs and symptoms, is, happily, seldom seen. The common picture is rather that of a subacute, low-grade infection, with slowly progressive degenerative changes in the vitreous, an easily irritable eye with, however, but little actual pain, and progressive lowering of vision which often becomes blindness as the plastic changes which gradually supervene produce shrinking of the vitreous, detachment of the retina, or end in frank vitreous suppuration and panophthalmitis. Frequently, however, these eyes never pass beyond the stage of ''irritable eyes'' and it will probably take the accumulated experience of years to determine the outcome of these latter degrees of infection and whether such eyes must be regarded and treated as a menace, or whether a final subsidence of the inflammation may be expected under symptomatic treatment. Lister (*Lancet,* July 20, 1918) in a discussion of the pathological features of these cases of exogenous panophthalmitis remarks that occasionally after a penetrating injury, when all seems to be going fairly well except for continued injection of the eye, one sees, a week or ten days after the injury, a white reflex behind one portion of the lens. It may be wrongly inferred that panophthalmitis has set in; the eye is removed, but on section and microscopic examination it is found that the retina has been drawn forward at this point by the shrinking of plastic exudate, from the ora serrata to the back of the lens. Lister further dilates upon those surprising cases of inflammatory involvement of the optic nerve, at times with consequent atrophy, which follow certain cases of corneal ulceration or of infection of the anterior part of the eye, the apparent lack of continuity of the infection being explained by the transference of toxins or of organisms along the lymph channels in the vitreous, of which Cloquet's canal, forming a direct means of communication, is probably the chief atrium.

Practically all of these cases of low-grade infection have the common trait of an intense reaction to operative procedure, whether this be early or delayed. This tendency makes the treatment of retained foreign bodies much more unsatisfactory than those dealt with in industrial life, in that this reaction is the frequent precursor of destruction of the eye from suppuration. This subject will be treated with additional detail under the heading of intraocular foreign bodies.

Injuries of the eyeballs, the orbits and adnexæ are considered under the headings which follow and, for greater fullness of detail, it is suggested that these sections be read with the corelative passages of the companion essay on **Military ophthalmology** in Vol. X of this *Encyclopedia:*

I. OCULAR INJURIES FROM CONCUSSION AND CONTUSION.
II. OCULAR INJURIES FROM PENETRATION.
III. THE PROBLEM OF ENUCLEATION.
IV. SYMPATHETIC OPHTHALMITIS.
V. INJURIES OF THE ORBITS AND ADNEXÆ.

I. OCULAR INJURIES FROM CONCUSSION AND CONTUSION.

These may be grouped into (a) *direct concussion* injuries from the tremendous atmospheric compression and decompression which accompanies nearby shell or mine explosions; (b) the effects of violence applied mainly to the orbital buttresses and walls and to the adjacent facial bones and transmitted thence to the ocular coats via the orbital fat. This constitutes *indirect or transmitted concussion;* (3) *direct contusion* of the eye, without penetration.

Direct or air-concussion. This war has removed the question of air concussion injuries of the eyes from the realm of controversy and has established as a fact that lesions of the inner coats of the eye may be caused by concussion from a distance, the force reaching the eye wholly through the air, and while not sufficient to rupture the dense sclerotic, yet is enough to injure the more delicate choroid and retina. Testimony to this effect has been so conclusive that Lagrange (*Atlas d'Ophthalmoscopie de Guerre,* 1918), has formulated as a "law" the following facts which concern this form of injury of the intact eyeball: "The commotion of the air caused by the explosion of a shell at a distance may injure the eye so severely that the inner coats are lacerated. There exist well-proven cases of luxation and subluxation of the lens and of traumatic cataract by this mechanism." The lesions of the fundus in air-concussion, as in indirect concussion, mainly involve the macular and paramacular area although other parts of the retina and choroid may be involved.

In nearly every case of concussion a *disturbance of accommodation* is produced, varying from the irregular spasm which is productive of a refractive myopia and which is reduced by the use of atropine, to variable paralyses or pareses of accommodation, the majority of which ultimately clear. Transitory astigmatism not uncommonly follows this type of injury. McKee (*Canadian Med. Jour.,* Feb., 1918) is confident that the cases which he reports are illustrative of permanent myopia caused directly and wholly by concussion of the globe (windage). Leplat (*Archiv. med. Belges,* May, 1917) describes the case of a soldier who was looking toward a mortar a few feet distant at the moment of firing. The vision was immediately reduced and examination showed hyphema, ciliary injection, and unequal pupillary dilatation under atropine. The eye became normal in 16 days.

Cassimatis (*Year Book,* 1916, p. 359) reports the case of a soldier who was knocked unconscious by the nearby explosion of a shell of large caliber, without having been struck. When he recovered consciousness he experienced such violent vertigo that he was unable to stand or even sit up. In this condition he was sent to a hospital, where no evidence of direct wound could be discovered. About a month later he was seen by the reporter for an ocular examination. The man could hardly sit up. The pupils were large, almost immobile to light; the sight of one eye equalled only light perception, the other counted fingers at 20 cm. Ophthalmoscopic examination of the fundus showed marked discoloration of both papillæ, but no other appreciable intra-ocular lesion. The reporter concludes that this was an instance of descending optic atrophy caused by the windage from the shell.

Evans (*Tr. Ophth. Soc. U. Kingdom,* 1916) reports irido-dialysis and subluxation of the lens as an air-concussion effect and Milady ascribes to the "windage" resulting from the explosion of a hand grenade the appearance of delicate radiating opacities in the cortex of the lens, with ray-like opacities extending from the center to the cortex. These were observed eight days after injury and disappeared completely under the use of dionin and heat, vision rising from 6/36 to 5/12 in eleven days.

Lawson (*Brit. Jour. Ophthal.*, Oct., 1917) notes detachment of the retina at the ora serrata following the explosion of a bomb nearby.

Ormond (*Tr. Ophth. Soc. U. Kingdom*, Vol. XXXVII, p. 60), despite having been assured that the explosive force of modern shells, often equalling a pressure of 10,000 kgrm. to the square meter, is such that the lids have been torn away and the whole eye dislocated by the force of the displaced air and expanding gas, nevertheless considers that a major injury of this sort is not yet definitely proven.

McKee describes a condition of traumatic retino-choroiditis characterized by diffuse cloudiness of the retina, numerous small exudates in the choroid, and fine dust-like opacities of the vitreous. It is identical with retino-choroiditis of secondary syphilis. It varies in degree from a very slight opacity of the vitreous to diffuse thick opacities with changes in the choroid. He has seen a large number of such cases in which he is positive the changes were due to trauma (windage).

Frenkel (*Ann. d'Ocul.*, cliv, 1) pictures the interesting case of a soldier, exposed to terrific explosions of shells in the trenches, who, without having been hit, noticed that his right eye was blind. When examined eight months later a diagnosis of optic neuritis and chorioretinitis was made. The Wassermann was positive. After a few months of antiluetic treatment Frenkel found a partial optic atrophy, with five white circles arranged above and below the papilla. Two of these above, each about 1 mm., showed a few small white dots along the arteries passing within the zone of these circles. Two of the lower circles were somewhat larger than the upper and one showed a partly absorbed hemorrhage at its lower periphery. The adjoining retina was whitish. The fifth circle, occupying ¾ of a circle, situated in the lower, inner quadrant of the fundus, showed three whitish patches, probably due to old hemorrhages. The left eye was normal. Frenkel regards this appearance as due to circular folds of the retina produced by the impact of the posterior pole of the globe against the tip of the orbit during the sudden increase of air pressure caused by the explosion of shells about 2 meters away.

Harriet (*Arch. d'Ophtal.* Vol. 35, No. 9, p. 374, 1916) observed unilateral posterior polar cataract following the explosion of a shell, a few meters away from two soldiers who were near each other at the time. Nine days later there was no sign of wound of the eyeball in either case. In one there was a small superficial scar at the lower border of the orbit near the nose. In each case there was persistent mydriasis, and a stellate opacity at the posterior pole of the lens, which latter became opaque throughout, in both patients.

Descomps, Enziere and Merle (*Bull. Soc. med. d'Hôp.* v. 42, p. 385) have noted some interesting effects of shell concussions upon convergence. At one of the army centers of neurology it was noticed that the eyeballs were found intensely converging after the rotation test; and from ten to ninety seconds elapsed after the close of the test before the eyes resumed their normal position. In the nine cases described in four this convergence of the eyeballs was the only sign of anything wrong in the oculomotor sphere. But in the other five cases there was paresis of some of the neuromuscular apparatus of the eyes. The writers of the report regard the convergence as the equivalent of paralysis, and theorize to explain its mechanism, saying that it is a mistake to think that all the symptoms elicited by the rotation tests are referable to internal ear. All these men were "commotiones," and some had traces of evident organic central lesions from the shell concussion. The probability is, they think, that this convergence sign is a manifestation of some minute focal lesion in the brain.

Similar paralysis has been noted by Lortat-Jacob and Hallez, who report (*Bull. Soc. med. d'Hop.*, v. 42, p. 34) the case of a soldier who was left with the Claude Bernard-Horner syndrome after subsidence of the usual nervous disturbances from severe shell concussion.

Lagrange (*Atlas d'Ophtalmoscopic de Guerre*) describes and pictures five chorioretinal lesions from this source which include hemorrhages, choroidal tears and later pigmentary changes about the posterior pole, as in direct and indirect contusions of the eye.

It is seldom possible to differentiate between the effects produced by direct contusion and by indirect or transmitted concussion, and the pathology evoked by these quite dissimilar forms of violence accordingly will be considered as identical, save for the single exception of direct corneal contusions, which have little or no counterpart in corneal lesions derived from indirect concussion.

It had been recognized long before this last war, that the blunt and relatively slow moving civil traumas applied without direct ocular injury to the frontal bosses and malar bones, the superior and inferior maxillæ and especially to the orbital buttresses, were not infrequently followed by intraocular lesions such as lenticular displacements, iridic deformities and pareses, bleeding into the aqueous, the vitreous, the choroid, or the retina, retinal detachment and, somewhat less commonly, choroidal tears. It was not even remotely anticipated, however, that such lesions would occur in military injuries with the frequency and gravity which they finally assumed, Rollet and Velter (*Amer. Jour. Ophth.*, Vol. 1, p. 211), for example, having found three hundred and forty-three lesions of the deep coats of the intact eye among three thousand nine hundred and fifteen wounded, or 8 per cent. In 145 cases the impact of the projectile was directly upon the eyeball; in 128 the impact was upon adjoining structures, particularly the outer portion of the orbit. The writers grouped their cases under the following headings: 1st, detachment of retina, 43 cases; 2nd, detachment with exudation, resulting in proliferating retinitis or cicatricial bands, 37 cases; 3rd, rupture of the choroid, 133 cases; extremely variable in extent and position; 4th, choroidoretinal hemorrhages and resulting changes, 130 cases, of which 38 were in the macular region; 5th, concomitant lesions of the papilla from simple hyperemia to atrophy.

Lagrange (*ibid*) classifies such lesions according to their production by 1. general concussions of the bones of the face, without direct injury to the orbital cavity; 2. by projectiles acting on the bones of the face and fracturing the orbit, often with peripheral fundus lesions due to contact with extraocular tissues, acting as secondary missiles; 3. by projectiles involving the orbit behind the eyeball, which is not touched by the missile; and 4. by mediate or immediate contusions of the eyeball. This classification is further condensed into (1) lesions by concussion, (2) lesions by contact and (3) combined lesions. In lesions of the first order the concussion is truly aerial, or is accomplished through the bony facial structures, or through the corneal and transparent media, the orbital walls, floor, roof or cavity not being directly injured. In lesions by impact, as de Schweinitz states (*Amer. Jour. Ophth.*, May, 1919, p. 313) there is traumatism of the frontal region and radiating fracture of the orbital vault, or passage of a missile through the orbit behind with injury of the optic nerve, but not of the bulb, or passage of a missile through the orbit tangentially to the eye, grazing it but not rupturing the globe. Should the lesions of the inner membranes result from a concussion at a distance, their development has been attributed to the commotion of the air-column shaking the ocular wall in the same manner as it shakes the door in a room. Should the concussion waves reach the eye in a line of transmission through the bony facial structure, the effect has been likened to the lifting up and shaking of a ship by a ground swell, and the entire adipose envelope is concussioned, resulting in ruptures of the inner ocular coats (Lagrange).

In this connection it may be interesting to quote from an editorial review of Bonnet's recent contribution to the study of the effect of shell explosions on the human organism, published in the *Journal of the American Medical Association*, February 8, 1919. Bonnet explains the nervous and pulmonary lesions which follow shell explosions by assuming "that the aerial wave-compression acts primarily on the superficial capillaries and bloodvessels, as well as those of the abdominal cavity; in short, those not protected by nature from pressure. There is thus formed a blood column which is driven like a battering ram into incompressible cavities, like the thorax and the cerebrospinal cavity. As a result the smaller vessels in these cavities may rupture, causing varying amounts of injury. The eye and the ear are especially liable to suffer, the former by its position exposed to pressure, and the latter by its physiologic adaptability to receiving pressure."

Lister (*Lancet,* July 20, 1918, p. 67), discussing the sites at which concussion changes occur states that:

"Blows on the front of the eye give rise to changes as a rule only at the posterior pole, at or around the macula. While missiles passing through the side of the orbit may cause concussion changes at three different situations: (1) Adjacent to site of impact; (2) at macula; and (3) immediately opposite site of impact..

"(1) The area which is always concussed is that adjacent to the site of impact. (This is strikingly in contrast to rupture of the sclerotic from a similar injury, which frequently takes place exactly opposite the place of impact, as already noted.) So constant is this that in certain cases of wound on one side of the head, with no apparent disturbance on the other side with the exception of some blurring of vision, the ophthalmoscope by revealing concussion changes in the eye of this side will enable us to state with certainty, not only that a foreign body has passed across the head and through the orbit on the opposite side to the wound of entrance, but also to define its course—a piece of information which may be of great value to the general surgeon.

"(2) The concussion changes found at the macula from blows on the front of the eye are common, and would be anticipated as the result of bruising at the site of contrecoup, but macular changes due to blows on the side of the eye are difficult to account for and the subject needs elucidation. The greater vascularity and delicacy of structure in this region renders it in all probability more vulnerable. They are often in a group quite distinct from the disturbed area adjacent to the site of impact, and a band of normal retina may separate the two. Such cases have corresponding fields of vision, which show two defects, a central or paracentral scotoma and a peripheral defect, separated from one another by a band where vision is retained.

"(Commotio retinæ may also occur in two distinct patches—one central, the other peripheral—as has been described by other observers.)

"(3) In some cases of a lateral blow on the eye hemorrhages were seen immediately opposite the site of impact, which corresponds with the bruising of the brain at the pole opposite to the point struck, and also with the site of the contrecoup rupture of the sclerotic."

de Schweinitz makes the interesting note that a concussion sent through the maxillofacial area of one side with the production of ipsolateral ocular lesions is probably prevented from producing like lesions in the opposite eye because the nasal accessory sinuses prevent the passage of the concussion or shock to that globe.

In the majority of these injuries there are no external indices of the grave intraocular damage, a fact which makes routine ophthalmoscopic examination imperative not only in the case of every head injury but also of every soldier wounded by high-power explosives. A reduction of intraocular tension, often of degree, frequently occurs and, as Treacher Collins shows (*Ophthalmoscope*, July, 1916) the contusion hypotony may be restored to normal in a few days or weeks, or in some cases apparently becomes permanent. Collins (*Arch. Ophth.*, Sept., 1918, p. 476) further considers as sequelæ of hypotony many of the later conditions more commonly looked upon as direct effects of the traumatizing violence, thus ascribing striate opacities of the cornea to the wrinkling of its elastic laminæ and the immediately adjacent substantia propria as the result of the relaxation of tissues usually kept taut. He similarly explains the choroidal pigmentation so often seen after contusion and concussion as the product of similar wrinkling of the elastic lamina of the choroid with a consequent heaping of the pigment epithelium at those points where the folds occur and he considers the refractive changes following contusion as results of displacement forwards of the lens system, which tends toward the production of a more or less transitory myopia. Collins finally asserts that exudation of lymph takes place into the various intraocular spaces as a result of the difference between the relatively higher blood pressure and the lower intraocular pressure and that this exudation accounts for detachment of the ciliary body and choroid, and retina, for a coagulable aqueous and for the edema of the papilla resembling choked disc which occurs occasionally and which may be followed by optic atrophy. Magitot (*Amer. Jour. Ophth.*, Vol. 1, p. 587; Vol. 2, p. 65) considers the variations in intraocular tension as the effect of trauma upon the choroidal sympathetic plexuses which regulate the intraocular vasomotor system.

The changes which occur as the result of ocular concussion and contusion may be given regionally as:

(a) *Striate opacities of the cornea (striate keratitis)* due to rupture of its anterior layers, giving rise to straight or curved superficial striæ. Lister (q. v.) states that sections through such striæ show a rupture of Bowman's membrane and of a variable number of the anterior layers of the substantia propria, with a growth of epithelium into the gap thus made comparable to its growth into a wound of operation at the limbus. These striæ, though often similar clinically, are different both in origin and in microscopic structure from the nearly straight, radiating anterior striæ met with in soft ruptured eyes, which are due to folding or crinkling of Bowman's membrane. The latter radiate across the cornea from the line of rupture in the same way that the posterior striæ, due to folding of the posterior layers of the cornea (i. e., the ordinary striate keratitis), radiate from an operation wound when there has been much bruising of the corneal tissue or when cyclitis has supervened. The forms of striate keratitis seen in association with lowered tension and which disappear within a few days are merely the effects of folding of Bowman's membrane.

(b) *Blood-staining of the cornea* occurs in concussion injuries as an accompaniment of very extensive intraocular hemorrhage. The discoloration may involve a part or all of the cornea save its extreme periphery and greatly resembles an interstitial keratitis. As is beautifully shown in v. Szily's *Atlas* (Plate 48) clearing takes place slowly and usually from the periphery, although sector-shaped clearance forms have been noted. In such cases there is usually such distension of the anterior chamber with blood that the lens system and iris are pushed back strongly. Bleeding of this extent is not infrequently but one phase of (c) *multiple intraocular hemorrhages* involving, as well, the vitreous and the retina, as inter- and subretinal hemorrhage and causing irreparable damage to nutrition and vision.

Maghy (*Amer. Jour. Ophthal.*, Sept., 1919, p. 633) who studied three cases of blood-staining of the cornea in enucleated eyes, one case following a gas burn of the cornea, concludes: 1. The highly refractile bodies seen in the corneal stroma in cases of blood-staining of the cornea are pigment granules transformed from hemoglobin. 2. Hemoglobin gains access to the cornea by diffusion through Descemet's membrane. 3. The discoloration is due principally to the pigment granules although blood corpuscles may be associated. The degree of the discoloration varies according to whether hemosiderin or other hemoglobin derivatives are present. 4. The staining never affects the extreme periphery on account of the efficient lymph circulation at the limbus, nor do we find pigment granules in this area. 5. The presence of an iron reaction seems to depend on the vascularization of the tissue.

(d) *Injuries of the iris and ciliary body* from concussion are very common and will be found, to some degree, in nearly every case if carefully sought.

In the lightest form of such damage there is accommodative spasm with little or no refractive change, though traumatic myopia is not uncommon and hyperopia and traumatic astigmatism may occur. In the severer injuries partial or complete iridic paresis or paralysis may occur and according to the nature of the lesion may clear or may persist.

The irregularity of the pupil may assume any form in consonance with the degree of the lesion, thus the iris may show rents, perforations, notching of the pupillary margin, rupture of this margin, partial or total iridodialysis, semicircular foldings and retroplexions of the iris, and separation of the posterior pigment layer from the overlying stroma of the iris and ciliary body producing "apparent iridectomy." Iridodonesis is commonly associated with the lens displacements. The pupil is frequently dislocated and is most often dilated, the pupillary margin assuming racket-shaped, oval, crenated, dumb-bell and other irregular shapes.

(e) *Concussion cataracts* are relatively common sequelæ and often occur in conjunction with iridodialysis or dislocation of the lens. Progressive opacification is not the rule unless the capsule is ruptured and extensive cortical changes may diminish or even disappear, while spontaneous absorption of the intumesced lens is not unnoted.

Whiting has classified concussion changes of the lens according to the position and shape of the lens *opacity* as follows: 1, posterior cortical (a) stellate; (b) irregular, probably arrested development of a stellate opacity. 2, anterior cortical, (or subcapsular) (a) annular, (b) disco-annular, (c) discoid, (d) double discoid, (e) stellate, (f) irregular. He describes each of these varieties somewhat at length and relates a series of cases, 32 in number, including examples of all the above varieties.

Frenkel thinks that traumatic subluxation of the lens is much more common than is generally supposed. He groups cases under two headings: (a) typical, diagnosis certain; (b) atypical cases, difficult to diagnose and in which the following are the most valuable signs: (1) Existence of a fold in the iris concentric with the circulus major and limited to a portion of the circumference, shown by a single (sometimes double) line, produced by the close apposition of the iris to the edge of the subluxated lens; (2) diminution of the pupillary reflexes, and partial mydriasis; (3) unilateral corectopia; (4) minute tears in the iris, near the root, or in the sphincter area; (5) retroversion of the iris at the free edge of an iridodialysis; (6) partial traumatic cataract; (7) acquired myopia or hypermetropia. He describes three varieties of displacement of the lens; (a) rotation on an equatorial axis; (b) backward displacement; (c) forward displacement which he notes is most often overlooked. Combined and irregular displacements are not rare. In the ophthalmic center of Toulouse subluxation was diagnosed in 2 per cent. of the cases occuring in 1915 and in 7 per cent. of 518 cases seen in 1916.

Experience indicates that in the majority of contusion cataracts it is better to defer operation unless urged thereto by the development of acute symptoms. Dislocated lenses should be removed if possible but, if merely subluxated, should be left alone.

Rollet and Velter (*Clin. Ophtal.*, vii, 7) saw 40 cases of traumatic cataracts without wounds of the globe among 237 traumatic cataracts occurring in 25,000 eye cases and consider the operative indications for this condition to be: 1. Luxation of the lens or its complete opacification; 2. hypertension which does not yield to miotics, and, 3. Very poor vision in the other eye. They consider hypotony an absolute contraindication to operation even with a complete cataract as it often indicates a latent iridocyclitis which may flame into a manifest lesion with any operative trauma. Where vitreous and retinal hemorrhage have taken place and where iridodialysis, retinal detachment or choroidal rupture have occurred it is well to await the possibility of spontaneous absorbtion.

Frenkel (*Ann. d'Ocul.*, Feb., 1918, p. 78) has grouped the concussion and contusion injuries of the eye from the cornea to the lens-system, inclusive, under the term of "The Traumatic Syndrome of the Anterior Segment of the Eye." Exception may be taken to the recognition of so limited a clinical entity, especially in view of the almost invariable coexistence of more or less grave lesions in the vitreous, in the ocular coats which form the fundus and in the optic nerve. The frequency and gravity of such lesions is recognized by the proponent but he classes them merely as "complications" although from their nature they may represent the most destructive of the lesions present, as well as the chief origin of the low vision which usually follows such injuries, even after cataract extraction.

(f) *Vitreous changes* which occur in connection with concussion injuries are mainly those related to hemorrhage from the retinal vessels which bursts through the hyaloid into the vitreous and to its not rare sequel, even in non-penetrating injuries, of conversion of the hemorrhage and infiltration into fibrous tissue in the form of bands or fans of delicate fibrous tissue which may attach in front to the back of the lens or ciliary body and behind to the retina. The hemorrhage and resultant fibrous bands may ultimately produce shrinkage of the vitreous and puckering, folding or actual detachment of the retina, although such sequels are much less common after concussion injuries than after penetrating wounds. In the severer hemorrhages liquification of the vitreous occurs with the formation of extensive masses of exudate and broad detachment of the retina.

(g) *Chorio-retinal lesions* are common results of concussion and contusion injuries and range from the almost constant traumatic edema of the retina, through hemorrhage into or between any or all of the ocular coats, tears of the choroid and retina, either separately or combined, detachment of the retina, evulsion of the optic nerve "holes at the macula," late pigmentary changes in the macula and retina and finally to the grave sequels of blindness from progressive intraocular degenerative changes or ascending optic atrophy.

Traumatic edema of the retina, first described by Berlin as "commotio retinæ" differs from the civil type in that hemorrhages are more numerous, the tint of the retinal haze is yellowish, its duration is longer, it is more circumscribed, and persistence of stippling, pigmentation and visual defects is more common. Lister (q. v.) states that cases are seen where early pigmentation of the macula follows commotio, either as fine peppering or as somewhat diffuse greyish-brown spottings and cites the case of a man who had an irregular scotoma, which had the same pattern as the pigmented area of the retina. The scotoma disappeared in the course of about three weeks, but the pigmentation persisted.

Lister further noticed that in the late stages of commotio retinæ, when the white haze has disappeared, for several disc diameters round the macula the retina may have a peculiar striated appearance, evanescent in character—that is to say, the striæ change their position with alteration in direction of illumination, like the rippled-sea-sand retina, suggesting that the retina is still somewhat swollen and wrinkled.

Where the fundus has been "grossly concussed," without obscuration by vitreous hemorrhage "in the early stages there are widespread, rich red clouds of hemorrhage, interspersed with gleaming white patches," which represent areas of coagulation necrosis from rupture of retinal and choroidal vessels and which gradually become converted into fibrous tissue. Where hemorrhage has occurred and has become absorbed retinal lesions and choroidal ruptures are frequently revealed. We find not only the usual crescentic type situated near to and concentric with a disc, but occasionally others are seen radial to the disc and usually more peripheral. In addition we frequently meet with more or less stellate ruptures, both adjacent to the part of the globe struck and also at the macula.

de Schweinitz (q. v.) summarizing our knowledge of these chorio-retinal lesions remarks that: "Lacerations of the choroid and retina, or of their vessels, or of both, followed by hemorrhage beneath the retina and into the vitreous, are common. They depend in part upon stretching of these membranes by the vibrations in the vitreous. They are frequently placed at the posterior pole of the eye and near the papilla. These situations are peculiarly liable, according to some observers, probably because the sclera, thicker around the entrance of the optic nerve than elsewhere, does not readily stretch. Its resistance in this regard causes the effect of the force to be more potent on the tissue just in front of it. Accumulation of transuded serum and of hemorrhage between the choroid and retina, and between the choroid and sclera, may cause detachment of the retina and of the choroid.

"The lesions just recited are *primary,* whether due to concussion, contusion, or impact. They naturally lead to the *secondary* lesions, the most important being atrophic chorio-retinitis (spots of atrophy, exposed scleral areas and pigment distribution, heaping and fringing), and proliferating chorioretinitis. If the extravasations on the retina and choroid are absorbed, many of the well-known appearances of pigmented atrophic chorioretinitis are evolved, though frequently its elaboration is most extensive, especially in fan-shaped, pigmented granular areas. Morax and Moreau, in fact, contend that many of the apparent choroidal ruptures are but zones of depigmentation. Blood may escape, and often does, into the vitreous and be absorbed, leaving all manner of opacities in its place.

"This chorioretinitis proliferans is essentially a cicatricial process: there is organization of hemorrhage, but this is of less importance than its irritating effect on the connective tissue of the retinochoroidal layers, inciting the active proliferation and the formation of tracts, areas and masses of fibrous tissue. The whole process and picture differ materially from the so-called proliferating retinitis of recurring hemorrhages in the vitreous and retina, especially in young subjects, often noted in civilian practice. In the type which follows war injuries the retina and choroid have been ruptured, and the cicatricial process leads rather to a pinning down of the retina by opaque, plastic-looking material than to its detachment, so frequent in the ordinary variety, in which the proliferation arises from extravasated blood, and the numerous membranes, following the vessels, often partly translucent, protrude freely into the vitreous."

Lagrange (q. v.) gives the following table of chief differential diagnostic points:

COMPARATIVE TABLE SHOWING THE DIFFERENCE BETWEEN THE CLASSICAL PROLIFERATING RETINITIS AND TRAUMATIC PROLIFERATING RETINITIS.

Classical proliferating retinitis is produced by organization of the extravasated blood. It may exist without foregoing hemorrhage.	Traumatic proliferating chorioretinitis is always consecutive to a hemorrhage and to a rupture of the inner membranes.
Membranes with numerous processes; appearance of a cobweb covering a large extension of the fundus.	Fibrous patch of a more regular thickness.
Membranes translucent at certain points.	Opaque everywhere.
Protuberances ending freely in the vitreous.	Simple proximity to the vitreous.
Pedicles, polymorphous masses, irregular surface, marked prominence.	Smooth and even surface without marked prominence.
Is located in any part of the retina.	Much more frequent in the macula, and disc and adjoining parts.

Foci of pigmentation rather frequent.	Foci of pigmentation very frequent.
Is often complicated by retinal detachment produced by traction of bands.	Not accompanied by detachment following the proliferation; on the contrary this latter binds the retina to the choroid.

Lagrange reaches the general and possibly not fully established conclusion that "Lesions by concussion are choroidal lesions, those by contact are chorio-retinal."

Lagrange (*Les Fractures de l'Orbite par Projectiles de Guerre,* 1917) has introduced a novelty in the treatment of retinal detachment in the form of "comatage," which consists of dissection of the conjunctiva from its position over the entire ciliary region between the insertion of the recti, with cauterization of all of the region of Schlemm's canal. By this means the filtration spaces in this region are obliterated. As all sorts of experimental glaucoma may be produced by this procedure, it is clearly indicated in hypotonic, relaxed eyes only, there being no change from the accepted methods of treating other forms of retinal detachment. Complete reattachment occurred in 3 cases out of 135 so treated, while 8 showed improvement.

Obviously the merits of this procedure are still *sub judice.*

In concussion-contusion injuries of the eye "holes at the macula" have been noted by many observers. These are like floating detachment of the retina, are said by Lister to be less often seen in military injuries than in civil experience, the intense concentrated military traumas causing severe concussion changes rather than the less complicated detachments and simple tears.

The experience of American ophthalmic surgeons is opposed to that of Lister, in that de Schweinitz, Derby and Edward Jackson have all remarked the surprising frequency with which this unfortunate injury complicates severe concussion injuries. de Schweinitz found five typical cases in 26 concussion injuries of this sort, and Jackson shows that holes in the macula in civil injuries are much more frequent than the published literature would lead us to assume.

Lagrange and others have noted that central vision is at times lost without visible lesions in the macula. Such cases must not be considered as malingerers and the central scotoma which they exhibit must be explained as due to disorders more delicate than can be revealed by the ophthalmoscope. It has been suggested that a finer examination in such cases might reveal indistinct macular stippling or fine choroidal tears as the source of the visual deficit.

Treacher Collins (*Tr. Ophth. Soc. U. Kingdom*, Vol. XXXVII, p. 112) concludes from the histological examination of an eye enucleated for subchoroidal hemorrhage after a shrapnel wound, that it seems highly probable that both retinal commotion and macular holes may result from a temporary ischemia of the choroid due to compression of that membrane by subchoroidal hemorrhage. Cases of pigmentation of the retina following concussion injuries of the eye have been frequently recorded either in the form of dots or network. Similar ocular effects might conceivably be due to traumatic rupture of the ciliary arteries but of this there is no pathological evidence adduced.

When the commotio retinæ has passed away after a more forcible contusion than gives rise to simple retinal edema of Berlin, pigmentary disturbances of a varying degree commonly appear at the macula and may be associated with permanent impairment of vision. Haab (*Encyclopedia Franc. d'Ophtal.*, p. 674) met with this condition in 80 out of 29,437 patients. Haab states that: "The mottling and pigmentation are very often insignificant, especially in the beginning, or may be replaced by more distinct pale patches." Sometimes there is only slight separation of the pigment confined to a small portion of the foveal region, such as occurs in myopic or senile macular disease, while in other cases it appears in coarse, irregular patches, fine, pepper-like deposits or in corpuscle forms. Colin suggests that such pigmentary changes, like such changes elsewhere in the fundus from concussion, may spring from ischemias due to subchoroidal hemorrhage.

Pigment changes have been noted by Whitehead even where the ocular injury had been very slight and superficial, and Cridland emphasizes the frequency with which fine striation of the macula of the "rising sun" type followed very slight blows on the eye. These were noted from one to two days after the injury, were associated with a visual reduction to 6/9 or 6/12 which returned to normal as the striation waned, and the macula became normal in from seven to ten days.

Visual effects of concussion. Concussion may produce a profound impairment of vision both in lowering the acuity and in contracting the field of vision. In the majority of instances great improvement takes place in the early weeks, and in the milder cases recovery is complete, both in field and acuity; but in the severe cases there is some permanent loss of field, and the acuity remains persistently lowered.

No doubt the early improvement is due to the clearing up of the commotio and the superficial hemorrhage in the retina and also the vitreous hemorrhages; but the parts of the fundus where large interretinal hemorrhages or coagulation necrosis have occurred never recover, and there is a permanent defect in the field corresponding closely in shape with the disturbed area of the fundus.

It is important to remember that in severe cases of commotio, sight may be completely lost for a few days—a fact which may be of the greatest importance in deciding the fate of a wounded and concussed eye.

It is important to look carefully for *rupture of the retinal vessels.* These occasionally occur and their discovery will account for an otherwise inexplicable contraction of the field of vision.

Projectiles involving the optic nerve behind the eyeball, but without contact with the globe, may produce all variations of partial and complete lacerations of the nerve in its intraocular portion, which appear in the ophthalmoscopic picture as partial or complete evulsions of the nerve. The trauma is followed at once by hemorrhage, and after its absorption in the incomplete cases an irremediable atrophy of the nerve and blindness result.

The site of the optic nerve head, in the cases of total evulsion, is represented by a deep pit or "well," much more pronounced than the excavation of glaucoma, in which appear remains of the ruptured retinal vessels or at times intact retinal vessels and which in time usually fills with proliferating connective tissue as in proliferating retinitis.

Jackson (*Amer. Jour. Ophth.,* Vol. 1, p. 776) in an interesting discussion of this condition quotes Parsons' statement that the vessels refill through direct and indirect cilioretinal anastomosis from the anterior and posterior ciliary arteries.

When the injury involves the optic nerve in the retro-bulbar portion containing the central vessels, the usual result is ischemia of the central artery giving the picture of embolism. Even in cases where the nerve has been so lightly lacerated that the retinal circulation is undisturbed optic atrophy may follow the injury, while this result is inevitable with the more marked lesions. Bayonets, knives, sticks and shell fragments may produce these lesions.

Hematoma of the sheaths of the optic nerve, while seldom demonstrable clinically, must be a frequent accompaniment of the numerous contusions and lacerations which the optic nerves sustain in retrobulbar injuries by bullets, shrapnel, balls and shell fragments. Peripapillary hemorrhage is rare in these cases but the classical brownish pigmented ring about the disc appears later apparently as the result of the migration of hemic pigment, and, according to Lagrange, must be considered always as a sign of a hematoma of the optic nerve of old standing. Atrophy of the nerve usually results.

The "through-and-through" wounds and the oblique unilateral wounds which give rise to injuries of the optic nerve in the orbit are considered by Ormond (q. v.) as particularly serious in their ultimate results.

In the majority of these cases the bullets traverse the skull where the bones are thinnest and the air cavities most numerous. The exit or entrance scar is usually in the temporal fossa and the line of passage traverses the orbits, posterior ethmoidal cells and the middle or superior meatus of the nose. Owing to the proximity of this line to the base of the skull and the not infrequent presence of "starred" fractures there is no doubt that such wounds are far more dangerous to life than almost any other of the wounds leading to loss of sight. Many of these cases succumb to cerebral abscesses, meningitis or end in a lunatic asylum. Ormond recalls several cases where cerebral abscess or meningitis caused death some months after injury and declares that these wounds are potentially graver than their appearance would indicate.

As to the treatment of the concussion-contusion injuries of the globe de Schweinitz suggests that to stimulate the absorption of extravasated blood and exudation, the usual alterative, diaphoretic and lymphagogue remedies (the iodides, sweats and dionin), may be tried, as may electricity, especially for those eyes with much vitreous change. Thyroid extract is also employed. He is frankly skeptical whether remedial agents have much influence, and more than skeptical as to the value of subconjunctival injections. In a certain number of apparently severely concussioned eyes after long periods of time there has occurred notable improvement in vision.

Ormond (Abstr. *Arch. Ophth.*, Sept., 1917, p. 481) states that the electric coil is an unexcelled reliever of pain in such conditions.

Rupture of the sclera by contact injuries may occur either anteriorly or posteriorly, the latter as a consequence of the passage of a missile behind the globe, and peculiarly a military lesion. In civil experience ruptures of the sclera center just above, or above and internal to the cornea, where they lie about 3 mm. from the limbus. Similar tears may rarely occur in battle injuries but other forms of rupture unknown in civil experience usually occur here, such as equatorial tears, radial fissures, or large stellate ruptures which melt the globe into irregular petals, Y-and T-shaped tears, or bursting of the cornea forwards with extrusion of its contents, as the effect of contact of the missile with the back of the eye. As Lagrange points out with emphasis, there is a marked absence of partial scleral ruptures produced by depression of the equator. The projectiles striking the eye tangently make contact lesions. Some contuse the eye directly, others destroy it. There is no place in military ophthalmology for scleral ruptures at the ciliary region, and subconjunctival luxations of the lens.

The sclera is sufficiently elastic to permit the entrance of small foreign bodies without rupture, but when a large fragment enters the eye in front at high speed the radial ruptures created at the point of impact by the explosive effect which ensues, split the sclera into petal-forms which often extend back nearly to the optic nerve.

The speed with which a globe, so partially eviscerated and fragmented, is covered and altogether hidden by conjunctival overgrowth, is worthy of remark, and early in the war, before the dangers of retained uvea were known to general surgeons, it was almost a rule to find cases of direct anterior rupture so well buried by the conjunctival cover that the complete removal of the fragments was often a source of much difficulty and patient search.

II. OCULAR INJURIES FROM PENETRATION. INTRAOCULAR FOREIGN BODIES.

Approximately accurate and detailed statistics of the incidence of the various types of military eye injuries will undoubtedly be available at no distant date, but statistics of results, the definite means by which alone modern medical and surgical conclusions and therapy are infallibly tested, will hardly be gathered and refined into their final terms before another three to five years.

With the compilation of such conclusive data, however, the questions concerning the methods of treatment of foreign bodies in the eyes, the limits of safety in permitting the retention of such foreign bodies, their true relation, if any, to sympathetic ophthalmitis and the bearing of early enucleation upon the problem of ocular sympathetic lesions should be closely approaching their solution. Until such facts are established discussion upon these points must remain largely speculative and a matter of individual judgment and experience.

Military injuries of the eyes and orbits produced by foreign bodies differ from the penetrating and perforating injuries of civil life in the multiplicity or duplication of their lesions, in the frequency of non-magnetic and multiple foreign bodies, in the common occurrence of extensive associated lacerations, fractures and remote complications and, finally, and perhaps most signally, in the prevalence of infection introduced into eye or orbit by primary, and more especially by secondary missiles such as manurial earth and befouled defence materials of every conceivable kind.

Another elementary difference appears in the frequency with which operative interference in these cases is followed by the lighting up of active infectious processes which may flame into a panophthalmitis with enforced evisceration or enucleation, or which attain the same result through the development of a menacing, chronic, plastic irido-cyclitis.

It is clear therefore why the treatment of military ocular and orbital penetrations by foreign bodies is not as satisfactory as that of civil penetrations either in its immediate or in its final phases.

As nearly as can be ascertained by averaging all available statistics, wounds of the head make up about 10 per cent. of all operative cases reaching the evacuation hospitals, wounds of the brain furnishing about 21 per cent. of the head injuries and facial wounds including those of the eyes forming about 45 per cent. The character of the ground being fought over determines the proportion which eye injuries bear to military injuries as a whole. Löwenstein, (*Archiv. Ophth.,* Jan., 1918, p. 112) shows that, while wounds of the eyes form between 2 and 4 per cent. of the entire wounds in battles on plains and wooded hills, they make up 8 per cent. of the injuries in Alpine warfare, where 70 per cent. of the eye wounds are penetrations by fragments of stone, as opposed to 20 to 50 per cent. of penetrations seen under conditions of mobile and entrenched warfare.

Frenkel (*Arch. d'Ophtal.,* Vol. XXXVI, p. 193, 1918) discussing multiple intraocular foreign bodies, and their effect upon the prognosis of penetrating injuries, ascribes to this source the frequency with which enucleation becomes necessary, even after easy and seemingly successful magnet extraction. To determine this fact he made careful radiographic studies of 100 enucleated eyes chosen at random, finding foreign bodies in 59, of which 38 were multiple, one eye containing as many as 17 fragments and 4 containing metallic dust. Most of these bodies were so small that their extraction was impossible even with the strongest magnets unless by chance the magnet came very close to them. In two cases there remained a second foreign body in the eye after the first had been extracted with the magnet.

As Petit shows, (*Year-Book*, 1916, p. 359) the prognosis of foreign bodies which have lodged in the ciliary region is especially grave, and he has been struck by the number of such missiles found in eyeballs enucleated for unmanageable iridocyclitis.

Bits of steel fragments of shells, grenades, bombs and bullet-casings make from 40 to 60 per cent. of the intraocular foreign bodies, the remainder consisting of copper fragments, nickel bullet-casing, brass, powder, stone, earth, wood, straw and glass. The investigation of Morax and Moreau (*Ann. d'Ocul.,* Aug., 1916) into the nature of the injuries caused by the different varieties of projectiles showed that 54 per cent. of the ocular injuries from fragments of shells were caused by small fragments capable of having been stopped by as filmy a protection as that given by a gauze shield, which might stop spent or nearly spent fragments of medium size.

Small fragments rarely penetrate deeply into the orbit as they expend their energy in piercing the lid and sclera and usually lodge in the globe where, according to Whitehead, about 75 per cent. of all intraocular foreign bodies come to rest in the vitreous. In many cases of injury by rifle and machine-gun bullets the projectiles split into a multitude of tiny metallic fragments, a metallic dust, in fact, which tattoos the face, the conjunctiva and the cornea and even may have sufficient energy to penetrate to the depth of the lens and thus induce traumatic cataract, or rarely lodge as deep as the vitreous. In Hertel's series of 242 cases of intraocular foreign bodies both eyes were struck in 21 per cent. and not rarely several fragments lodged in one eye. The frank hemorrhages, the common occurrence of wounds of entrance through the closed lids with associated defects of the orbital margins, the frequency of double perforations and the penetration of particles as minute as 0.002 gm. into the posterior segment attest the usual great force of the impact.

From the view-point of prevention of ocular lesions by small foreign bodies Cruise *(Tr. Ophth. Soc. U. Kingdom,* Vol. XXXVII, p. 176) divides eye injuries into (a) the non-preventable, such as most injuries by bullets and the larger fragments of shells and casing,.and (b) that large class of cases in which it is clear from the nature of the damage that it was preventable. In such a group fall those cases of simple bulbar penetration, corneal abrasion and bulbar contusion with its varied picture of lenticular dislocation, traumatic cataract, intraocular hemorrhage and chorio-retinal lesions. The work of Cruise and others to the end of preventing these injuries, minor as to the force of the blow but of gravest importance in terms of vision or even life. is worthy of the highest commendation.

Cruise, examining 100 cases of blinded men at St. Dunstan's, found that even with rigorous exclusion 52 per cent. of these blinded eyes were the result of being hit by small missiles of low energy and easily preventable. Preventable eye casualties made up 65 per cent. of the cases in the 3rd London General Hospital.

As a means of prevention of such needless injuries Cruise devised a chain mail visor consisting of a transparent mesh of steel rings, so closely linked together that only the most minute particles could pass through its meshes and then only if impinging at right angles to the plane of its surface; a tangential blow would meet with a practically continuous barrier of steel.

The visor is fixed to the helmet and is therefore not a separate article of equipment to be remembered and attached to an already overloaded body. When not required it can be thrown up on to the brim of the helmet. The links have been rendered rust-proof chemically. It is said that soldiers did not take kindly to the use of this visor.

De Lapersonne's suggestion of closely woven wire grating, lined with a leaf of cellophane, Giusseppi's and Richardson's application of the stenopeic slit. both transverse and slanting, and the non-shattering triplex glass, made of two layers of glass with a middle layer of zylonite have been used with such success as war glasses for protective purposes and in aviation as to warrant continued effort in this direction.

De Lapersonne (*Arch. d'Ophtal.*, May-June, 1916) found about 20 per cent. of penetrating injuries of the eyes among 1,000 wounded soldiers with complicating traumatic cataract in 36 per cent. of cases, with preservation of vision from 2/3 to 1/20; slight iridocyclitis in 16 per cent., with vision from 2/3 to 1/20; and complete loss of the eye from iridocyclitis, in 47 per cent. Half of the cases of bilateral blindness had multiple penetrating wounds with small foreign bodies in each eye. the wounds ending in bilateral iridocyclitis. The corneal wounds were rarely clean cut, as in industrial injuries, and it was sometimes difficult to decide whether the perforations were single, multiple or whether there had been perforation at all. Prolapse of the iris, lens or organized vitreous were not rare complications. In perforating scleral wounds the wound of entrance was often concealed by chemosis or conjunctival injection and diagnosis was made by the diminished tension and a narrow anterior chamber. Lowered tension and an anterior dislocation of the lens system, as shown by Collins, may, however, be the result of hypotony following contusion and in such cases the use of the magnet or sideroscope, of the ophthalmoscope and of stereoradioscopy, are the final arbiters of the existence of foreign bodies within the eye although in an unconscionable number of cases even these diagnostic aids have failed. Careful stereoradioscopy and magnet testing done as a routine in all cases of eye injuries when the stress of battle permits has shown the unexpected presence of foreign bodies in the eye and orbit with surprising frequency and this procedure has further been of unexpected value in demonstrating at times that foreign bodies, presumably orbital, had really entered the cranial cavity. Additional symptomatic aids in localization are given at times when the concurrence of proptosis, chemosis and limitation of motion suggest the presence of a foreign body in the orbit. As is well known, loss of tension in association with a wound in the sclera or cornea by no means assures the presence of a foreign body within the eye, as it may have perforated the posterior coats and lodged in an extraocular though intraorbital position. In these cases the presence of a small degree of exophthalmus is often definite.

While the results of ocular penetrations by foreign bodies depend in large measure upon the degree of damage done to the interior of the eye and upon the generation or prevention of infection, it is almost trite to say that, in general the best results are obtained where the basic advantages of immediate diagnosis and prompt extraction, when possible, can be employed. Thus of the 252 cases of ocular trauma tabulated by Uhthoff early in the war *(Year Book,* 1916, p. 360) the majority of the deep perforating injuries were lost, although successful extraction of the foreign bodies saved a few. Opposed to this are the later optimistic statistics of Duverger *(Ann. d'Ocul.,* cliv, 10) who, with the advantages of quick transportation of the wounded and ample initiative and facilities, lost but ten eyes out of 100 such perforations. It is of particular importance that operative extraction be attempted before exudate can form around the foreign body and gravely complicate its removal.

Krusius (Abstr. *Arch. Ophth.*, Nov., 1917, pp. 593-4) dealing with the plastic covering of penetrating corneal and scleral wounds in order to prevent infection from without after the injury or after the extraction of a foreign body, a method widely advocated and fairly generally used by military ophthalmologists during this war, employed the method in 34 cases in which there appeared to be no infection and no foreign body remaining. Sixty-two per cent. of these were scleral wounds, 30 per cent. corneo-scleral and 8 per cent. limited to the cornea. No case developed infection and the final result was an unirritated and seeing eye in 31 of the cases, 3 eyes remaining blind, vision of less than 1/10 in 9 and better than 1/10 in 22. Four of these eyes were enucleated later as a measure of prevention against sympathetic ophthalmitis. Before the plastic covering of the wound in 27 of these cases successful extraction of brass or copper had occurred in 3 and iron had been removed from 24.

In Krusius' second group, consisting of 13 cases of plastic covering of wounded eyes, still able to see but all containing foreign bodies, and some of them infected, whose extraction had been attempted unsuccessfully, infection was inhibited or prevented in 12, one case going on to evisceration for panophthalmitis. In 8, signs of irritation persisted, while in 4, one of which contained brass and 3 with particles of stone, vision was preserved with a painless eye.

The immediate results in the third group of 18 cases of plastic covering of disorganized yet not blind eyes which retained their form were prevention of infection in 16 and panophthalmitis in 3. Eleven of these finally retained light perception, four had unirritated blind stumps and 3 came to evisceration.

This method attains special value after excision of prolapse of the iris which so frequently accompanies penetrating wounds of the anterior segment. Here, as Ramsay suggests (*Brit. Jour. Ophthal.*, Nov., 1918, p. 554) "After the parts have been carefully dried, a coating of paraffin is applied to seal the edges of the flap to the cornea and give additional protection to the wound: the paraffin employed is a substitute for ambrin and is known as No. 7; it is non-irritating to the eye and is readily applied in the liquid state by a medium-sized camel-hair brush: it becomes solid almost immediately.

"When the wound implicates the sclera as well as the cornea and the prolapse includes the ciliary body and cornea as well as the iris, with loss of vitreous, no speculum should be employed but the upper lid held back with retractor or strabismus hook. The bulbar conjunctiva should be separated from the posterior lip of the wound, and undermined freely for a considerable distance around the seat of injury. The whole of the prolapsed uvea must now be carefully excised, and the lips of the wound approximated by drawing the conjunctiva over the cornea like an apron, and fixing it securely in its new position by as many sutures as may be required—the fewer, however, the better. No attempt ought to be made to stitch the sclera."

Ramsay, considering the treatment of prolapse following penetrating wounds which has existed several days, points out the necessity of breaking down adhesions and the difficulties connected with such separation, and also the necessity for avoiding the entrance of sepsis into the interior of the globe. When the prolapse is small, it may be wisest to leave it alone although the subsequent danger of secondary glaucoma and the liability to future infection must be remembered; on this account it is advised to deal surgically with such prolapses, if prudent to do so, by separating the iris from the lips of the wound and excising and then removing any tags of iris tissue left behind with fine forceps or scissors. If the edges of the wound show signs of septic infection they should be touched with the galvanocautery, and afterwards covered with a conjunctival flap. In such cases, the writer is in the habit of giving 4,000 units of antidiphtheritic serum subcutaneously and a second dose of half this amount twelve hours afterwards; he has seen favorable results following the use of serum and advises its use confidently in all cases where the eyeball is infected. The use of massive subconjunctival injections of cyanide of mercury in strengths up to 1-1500 is also to be urged here, as in all penetrating injuries of doubtful progress and especially where infection is beginning.

Kuhnt states that in penetrating injuries painstaking examination of the wound canal should assure the removal of all infiltrations, shreds of the edges of the wound, enclosures or incarcerations of other membranes by knife, scissors or galvanocaustic wire.

If perforation has taken place in an approximately straight line, a correspondingly shaped flap should be used as covering. But if it is angular or there is a triangular or irregularly shaped tear, so that after trimming the edges these cannot be closely approximated, then it is advisable to incise the conjunctiva in the whole circumference of the cornea and at the limbus. It is then loosened about 1 to 2 cm. toward the equator, drawn over the cornea in a direction perpendicular to the perforation and sutured. The elastic conjunctiva will mechanically effect a more ideal union of the edges of the wound than could be accomplished with sutures, which are besides always extremely difficult to make. Only in those cases in which a narrow flap in the form of an acute angle has been torn out of the cornea or sclera should the tip of the flap be secured with one thin suture with catgut, as otherwise it might be pushed back into the anterior chamber. This employment of conjunctiva is mechanically antiseptic, since it not only excludes later ectogenous infection but also furnishes the best covering for the wound.

In war wounds the fraying, swelling or infiltration of the edges of the wounds frequently necessitates trimming or cauterization, especially of the anterior edge. In these cases a small pedunculated or non-pedunculated flap must be placed in the hollow before the conjunctiva is drawn over; and furthermore relaxing incisions must be made to prevent a too strenuous mechanical action, as otherwise a lasting flatness of the cornea might easily result.

Simultaneous injuries to lens or vitreous are of course treated at the same time according to the individual nature of the case. On the whole, plastic closure of the wound is sufficient in cases of traumatic cataract. Only when there is marked lenticular swelling present or to be feared, or when this swelling causes pain or intense irritation of the anterior vascular trunk, does one proceed to iridectomy, or if need be to extraction either through the preformed wound or through a special incision.

In cases of penetrating wounds of the sclera it is absolutely necessary to smooth off the edges of the wound and to remove with deep incision the prolapsed vitreous, following that, if necessary, with the galvanic wire cautery. After removal or reposition of the prolapsed uvea, the closing sutures should be placed through the whole thickness of the lips of the wound in the sclera, and not only through the outer edges.

Kuhnt states that his experience in more than 2500 cases justifies him in advising that an attempt with this operation should be made in every case in which it is not probable that infection has already taken place or in which unalterable pathologic changes are not to be assumed. If the case does not improve very soon, Kuhnt does not obstinately insist on the preservation of the frequently very slight power of sight or of the form of the eyeball, but employs timely measures for the prevention of sympathetic ophthalmia.

Aside from its obvious value in the prevention of extraneous infection after wounding or operative extraction, the use of this method has the further great advantage of rendering the wounded man fit for transportation. Undoubtedly many eyes so treated will have to be removed later but many others will be saved and with practical vision resulting even in cases usually considered beyond repair.

In the treatment of intraocular foreign bodies of military origin the generally adopted routine use of the X-ray for diagnosis and localization is often prevented by the tremendous pressure put upon the X-ray service in times of active action when practically every surgical case reaching the hospital has to be radiographed. It is naturally often impossible to hold men with such injuries where space is urgently needed for an ever-rising stream of gravely wounded, non-ambulatory cases and under these conditions it is better practice to dispense with accurate localization and to use the magnet for diagnosis and approximate localization. This is most safely done by applying the small magnet about the equatorial region of the strongly rotated eyeball. The presence of a magnetic intraocular foreign body even if quite small is almost unfailingly sensed by the patient as a slight pull, at times as a slight ache or pain and again merely as a feeling which is incapable of description but which is, nevertheless a novel and localized sensation. The use of the giant magnet for diagnosis may, in some cases, be decidedly painful, one of my cases describing his sensation as that of "trying to pull my head off while my eye was filled with painful flashes of blinding purple and blue light."

Of course where the eyeball presents a wound of entrance, application of the magnet to this wound is usually sufficient to establish the diagnosis and often to deliver the foreign body or bodies. Some men have become so skilled in the use and interpretation of the magnet that they feel they can make fairly accurate localization by means of a small magnet placed on the sclera.

The question as to the advantages of the anterior or of the scleral route of extracting intracular foreign bodies of military origin is made decidedly less controversial by the large proportion of non-magnetic missiles, which naturally make magnet extractions less successful in war than in peace and which furnish no great justification for uncertain "fishing" in the posterior segment of the eye through a scleral incision, unless by rare chance the missile remains in ophthalmoscopic view.

The bulk of opinion among the observers from all the countries engaged in the war is that the route of election in magnet extraction of foreign bodies situated back of the iris and lens is by the anterior route; in all cases where the anterior segment has been penetrated. Where the anterior segment is intact and uninjured there is a beginning and decided diversity of opinion as to the method of attack, the majority of the English and German operators holding that the anterior route should be used even under such conditions and despite the injury to a normal lens and iris which at times results with unusually uneven, spiculated or large foreign bodies or those which mechanically are intractable for no apparent reason. Many of the French and American ophthalmic surgeons believe that with the established presence of a magnetic foreign body in the posterior segment. extraction through a posterior sclerotomy can be done with reasonable safety, with a large percentage of eyes saved, better visual acuity and a decidedly shorter convalescence.

American ophthalmologists in particular incline to the belief that the fears of complicating chorio-retinal hemorrhage and of late retinal detachment as a direct consequence of operations by the scleral route are largely theoretical and that Hartridge's gloomy forebodings that "the majority of cases in which a foreign body is removed from the back of the eye through the vitreous end in retinal detachment" are hardly justified by the facts. The explanation of the retinal detachments which follow anterior, no less than posterior extractions in many cases, is, in fact, strikingly shown by Lister in his studies of the vitreous changes set up by foreign bodies, to be largely the effect of the organization and contracture of recent exudate along the path of the foreign body. It is, of course, true that hemorrhage into the vitreous with late organization and contraction and ultimate retinal detachment may occur in that particular sequence after a sclerotomy, but obviously the likelihood of such a calamity is far less after the delicately performed linear incision, close to the site of the foreign body, than when compared with the effects of the original trauma, with its frequently severe and extensive injury to the inner ocular coats. Foreign bodies enmeshed in the retina by exudate, or retained there owing to raggedness of outline are, of course, equally likely to end in retinal detachment when magnet extraction is essayed by either route. It is further clear that a nidus of infection forming about a foreign body in the vitreous is much more susceptible of relief through the employment of the posterior route.

In anterior extraction the foreign body is usually drawn into the lower part of the anterior chamber by a large magnet of the Haab, Volkman or large Lancaster type and is removed through the corneal incision or the original wound of entrance in the cornea by means of a hand magnet of the Sweet-Parker, Hertel or small Lancaster type. The Mellinger ring-magnet has been satisfactorily used by Butler and by Gibb, Juler and Moore (*B. J. Ophth.*, Nov., 1918, p. 564). The magnet tip is not inserted into the anterior chamber save when the foreign body is entangled behind the iris. Sometimes repeated applications of the magnet are necessary before the foreign body is shifted into a position more favorable for extraction.

Early in the war Lowenstein utilized the fixed magnet from the ignition-magneto of a heavy truck, with inverted U-tips attached, for the satisfactory removal of magnetic foreign bodies. Later the English and French found that a motor car with special body and equipped with a dynamo, run by the engine, so that a giant magnet could be carried about and furnished with a suitable and sufficiently powerful electric current, was very useful. Prior to the cessation of hostilities, various types of such motor cars were investigated by the senior consultant of the A. E. F. with the intention of recommending one for the medical department; but when the necessity for such a car no longer existed the project was abandoned. The urgency of such a portable outfit was lessened owing to the fact that our mobile hospitals had such electric current producing cars or had portable gasoline driven dynamos, delivering a direct current suitable for the magnets. Therefore, magnet equipments were placed with the more advanced and isolated of these hospitals.

Le Roy Thompson reports six cases of penetrating metallic bodies which resisted magnet extraction and which, after enucleation, showed the missiles to have been meshed in the sclera, where, it is reasonable to assume, they might have remained innocuously, if not accompanied by infecting material. Hertel (Heidelberg Ophthal. Congress, 1916, Abstr. *Ann. Ophthal.*, Jan., 1918, p. 113) ascribes the relatively poorer results of attempted magnet extraction of metallic foreign bodies from the eye in military injuries, to the lateness of operation, the greater force of impact, the more frequent multiple perforations and to the feebly magnetic quality of the metal owing to the large admixture of phosphorus and manganese with the steel. He notes that such admixtures seem to favor the early onset of siderosis. He reports about 30 per cent. of failures to extract metallic foreign bodies by the magnet.

The larger intraocular foreign bodies, if magnetic, are generally removed through the entrance wound. There is usually little hope of saving such eyes because of the usual hemorrhage and intraocular disorganization and where the foreign body is non-magnetic the usual practice is an immediate enucleation. If the missile can be extracted, however, it is often wiser to treat the case expectantly and enucleate only in the face of beginning infection or persistent irritation.

Morax (*Ann. d'Ocul.*, cliii, 10), writing on the prognosis of magnet extraction in 59 cases of foreign bodies lodged in the vitreous, reports that 13 eyes were enucleated; 18 had no vision or very poor vision; 20 were left with useful vision and 8 recovered completely. Fifteen cases of missiles in the lens, iris or anterior chamber gave the end results of one enucleation, one blind eye, 4 with satisfactory and 9 with excellent vision. The prognosis is best where the foreign bodies weigh from 3 to 5 mgs.

Treatment of the larger, non-magnetic or feebly magnetic foreign bodies is most unsatisfactory as infection or later degeneration are almost certain. Bits of brass, copper and lead are successfully removed in a few cases, straw, wood and glass fragments are removable from the anterior segment only and are nearly always followed by infection.

Boehm notes that injuries of the eyeball by fragments of lead occur in war when, as described by Handmann, the rifle ball strikes steel buckles, or stone in the wall of the trenches, or when it passes through sand. The aluminum covering of the ball breaks, the lead nucleus is melted and pulverized into particles of varying sizes, from a seed grain to a cloud of lead in a state of minute subdivision. The reporter has seen many such cases. The Roentgen rays render a great service in the detection of such foreign bodies.

In five enucleated eyes it was possible to demonstrate positively that the fragments were lead. Boehm relates cases showing that the injuries produced by the passage of lead to the fundus remained aseptic, and proving that fragments of lead, if introduced aseptically into the eye, behave more favorably toward the tissues than other metals; lead is doubtless but little soluble in the vitreous. The prognosis is good even as concerns sympathetic ophthalmia.

The treatment of the smaller non-magnetic particles is largely expectant. Powder and stone "dust" driven into the eye are often tolerated surprisingly well and, in common with many other very fine foreign bodies may become encysted in any of the tissues of the eye and cause no further trouble if not accompanied by infectious material. Data upon the final outcome of such cases is awaited with keen interest, as the future treatment of aseptic retained foreign bodies will be largely decided by these final results.

This frequent tolerance of the eye to single or multiple foreign bodies, both metallic and non-metallic, without reaction of any sort while under long periods of observation, has furnished one of the greatest medical surprises of the war. The common consequences of retention of foreign bodies within the eyeball are the well-known forms of iridocyclitis or, if not infected, connective tissue organization of the exudate with contraction, siderosis bulbi and all forms of slow degenerative changes. In these novel and unusual cases, however, the foreign bodies may not seldom be seen ophthalmoscopically on or in the iris stroma, in the lens where they may be unaccompanied by nebulosities, in the vitreous, on or in the retina and several cases have been seen of a metallic foreign body resting, unencysted, on the optic nerve head.

Terrien (*Arch. d'Ophtal.*) as Chief of the Ophthalmic Centre of the Ninth French Military Area, has dealt with a large number of cases of intraocular foreign bodies. While he advocates removal or attempted removal of the foreign body in the majority of cases, he is of opinion that in a certain proportion, especially when a moderate degree of sight is retained, it is inadvisable to operate. Such cases are those in which the eye has exhibited no signs of irritation, or, in other words, shows a marked tolerance of the penetrating particle. He publishes the notes of five soldiers, in each of whom the presence of a foreign body within the globe was proved by X-ray or ophthalmoscopic examination. In all these cases the wounded eye was free from pain, redness, or any other sign of reaction set up by the foreign body. In all of them the eye retained some sight, and in one, vision was practically normal. In one man the fellow eye was badly injured and nearly blind.

It is noteworthy that none of Terrien's cases remained under his observation for more than three months; hence the possibility of the onset of trouble after a long interval cannot be wholly excluded.

Parsons and Collins independently conclude that a sterile foreign body which is chemically inert does not of itself induce sympathetic inflammatory changes which are set up, rather, by infection or by the nature of the wound, as where the ciliary body is incarcerated. (This matter will be treated at greater length under the heading of *Sympathetic ophthalmitis.*)

Velter and Perrin (*Arch. d'Ophtal.,* xxxv 4) report two cases of intraocular foreign bodies visible with the ophthalmoscope through clear media and showing no inflammatory reaction.

In one case vision of 2/3 was retained, in the other, a particle near the macula, only light perception remained. In neither case was the missile disturbed.

Gibson (*Austral. Med. Gaz.,* July, 1918) reports the following interesting case of retained foreign bodies as an example of how nearly a man at the front may be blown to pieces and made blind, and still escape with useful limbs, a good throat and excellent sight. The right thigh and knee were badly smashed; the knee was permanently ankylosed, and there was still some foot-drop. The left hand had lost three fingers. Each shoulder was injured, and there was a large scar over the thyroid cartilage, showing where the larnyx was injured. There were small foreign bodies and powder marks all over his face, especially about his eyes and temples. There were foreign bodies in both orbits, and almost certainly a foreign body had gone through each eye, taking the lens in transit.

He was wounded on April 11, 1916, by an explosive shell, and seen by the writer in July, 1918, when his eyes showed the following: Right eye, two or three small scars, and one, two millimeters long, nearly central scar, in the cornea; also a stained one-millimeter scar on the lower inner side of the pupil and a two-millimeter hole in the lower iris, as if caused by the passage of a foreign body, now closed with organized exudation. "Occupying the pupil is the thick membranous remains of a traumatic cataract, to which the edges of the pupil are attached below. The upper part of this membrane is thin and admits some light. Corrected vision was 6/36. One of the foreign bodies shown by *x*-rays appeared to be in the vitreous chamber, but is probably in the outer coats of the eye posteriorly. Left eye, a large, nearly central, two-millimeter scar in the cornea. There were some dark spots on the cornea and under the ocular conjunctiva, either powder grains or small foreign bodies. Occupying the pupil were dense, membranous remains of a traumatic cataract. One part was thin, admitting some light. Corrected vision was 6/36. One of the foreign bodies shown by *x*-rays appeared to be either in the vitreous chamber or in the outer coats of the eye. Probably the latter."

July, 1918: Needling the right eye obtained a small, but sufficient, hole in the upper part of the cataract remains and without causing any reaction.

September, 1918: Needling the left eye obtained a sufficient opening in the cataract remains, and without causing any reaction.

After a needling in both eyes corrected vision was 6/6 with the right eye and one or two letters of 6/5, and 6/9 with the left eye and one or two letters of 6/6.

Binocular vision was better than vision with either eye alone.

Lagrange is of the opinion, and his belief is substantiated by the writer's experience, that if an eye contains a foreign body and still has useful sight it should be undisturbed, but if vision has departed and the foreign body is in the ciliary region the eye should be enucleated, even if devoid of pain or irritation. If the foreign body is elsewhere and the eye is quiet there is no indication for operative intervention.

Petit (*Ann. d'Ocul.*, cliii. 7) writing on the remote consequences of retained foreign bodies and of war injuries of the eyes, emphasizes the caution which is commonly felt in these cases by advising that eyes which are apparently without reaction should be watched from time to time. He has seen about 40 cases in which neither radiogram nor clinical examination revealed the presence of foreign bodies but in which, after a forced later enucleation, foreign bodies were found in the ciliary body, the vitreous and elsewhere and were considered as the inducing factor of the ocular reaction leading to the enucleation.

Dor (Abstr. *Amer. Jour. Ophthal.*, Nov., 1918, p. 209) reports symptoms of acute inflammatory glaucoma, traumatic cataract or intraocular infection caused by unrecognized foreign bodies which had entered the eyes through the sclera without a recognizable wound of entrance.

Morax (*Ann. d'Ocul.*, cliv, January, 1917) has noted glaucoma secondary to wounds of the eye by intra-ocular foreign bodies in five cases out of a thousand wounded. He excludes glaucoma secondary to irido-cyclitis following perforating injuries, with or without an intra-ocular missile, and the forms of glaucoma induced by the rapid swelling of a traumatized lens or by the contusion of the globe with lens dislocation. In his cases the glaucoma developed weeks or months after the original injury and the presence of the foreign body was established by extraction or radiography as the wounds of entrance were very fine. Glaucomatous attacks occurred in which the tension had risen sharply, with congestion and pain calling attention to the condition, while in others a poor visual result, despite the clarity of the pupil, led to the discovery of the increased tension. Miotics had little effect upon the tension. In one case there was an associated rupture of the choroid with adjacent hemorrhages and in another traumatic pigmentary and atrophic changes in choroid and retina, this eye revealing the presence of a very small piece of stone at enucleation. Morax states that the foreign body may be aseptic and non-metallic and may still cause tension just as a dislocated lens may do. There was no cyclitis.

The functional results of treatment were almost uniformly poor, as extraction of the foreign body, miotics, sclerecto-iridectomy and anterior and posterior sclerotomies, while often relieving pain, were nearly always followed by enucleation or evisceration. The unavoidable conclusion of these observations is that cases of chronic glaucoma following an injury of the eye in which an ophthalmoscopic study of the fundus is made impossible by the changes in the media, should be stereoradiographed, since the existence of an intraocular foreign body is not only possible but probable.

Traumatic cataract is a common accompaniment of penetrating eye injuries and, according to Rollet and Velter's statistics, occurs about five times as often as contusion cataract. Only 31 of Rollet and Velter's 197 cases showed intraocular foreign bodies associated with the cataracts and in such cases the authors counsel the immediate extraction of the foreign body and the simultaneous removal of the lens wherever possible. Foreign bodies in the lens are frequently small and so firmly fixed in the lental substance as to make extraction by magnet difficult, hence it is wiser to wait on complete opacification, a course made favorable by the well-recognized tolerance of the lens for small foreign bodies and the rarity of infection under such conditions. When the missile is behind the lens it is extracted by magnet as soon as possible and the cataract extraction may follow at the most suitable period when the reaction has wholly subsided. Some of the soft lens substance is usually removed during the extraction of the foreign body. When the attempt at removal of the foreign body fails the eye may be lost as a result of rapid inflammatory changes which, as an extreme rarity, may lead to sympathetic ophthalmitis; organization of the vitreous may take place about the foreign body and vision be gradually lost without active inflammation; or the eye may become quiet, without further visual loss, and the cataract may be extracted later when conditions most warrant. In 6 cases of traumatic cataract where the removal of the foreign body had been accomplished, Rollet and Velter obtained vision better than 1/4 in 2 cases, between 1/4 and 1/20 in 2 and worse than 1/20 in 2, while in 12 such cataracts where the foreign body could not be extracted vision was better than 1/4 in one case, between 1/4 and 1/20 in 3 and less than 1/20 in the remainder.

The majority of cases of traumatic cataract with no retained foreign body in the eye are associated with a penetrating wound of the anterior segment of the eye which is often found blocked with lens matter and prolapsed iris, to free which an immediate operation is usually necessary. Where the wound is large and the capsule is torn an immediate extraction is indicated, as is also the case in the presence of hypertension which does not respond to miotics. Wounds extending to the posterior half of the globe with damage to the choroid and retina, with symptoms of infection such as iritis and iridocyclitis with hypertension contraindicate operation, as do obviously, those wounds with complete loss of light perception. No eye should be operated upon in which a low-grade iridocyclitis exists, especially if there is a little hypotension, until the lapse of several months or even a year, on account of the danger of a fulminating cyclitis.

Vision of 1/4 or better was obtained in 12 out of 89 cases of traumatic cataract associated with penetrating injury; in 36 cases vision of 1/4 to 1/20 was obtained; 18 cases gave 1/20 to 1/50 and in 23 cases vision of less than 1/50 resulted.

Löwenstein (q. v.) referring to the final effects of penetrating wounds of the eye in general, noted that but 17 blind eyes required enucleation out of 133 such injuries.

Aubineau (*Clin. Ophtal.*, vii, 4), comparing cataract and aphakia from the military point of view, believes that as the liability of the state is much less in the case of aphakia than in the case of soldiers with unoperated cataractous eyes, operation should be urged in every operable cataract, a view opposed by Valude (*Ann. d'Ocul.,* cliii, No. 3) on the sole ground that cataract operations are inopportune. Operation for cataract in the case of civilians whose induction into military service might be desirable on other grounds is, in general, unwise, in that the starting point for a pension is provided.

Teulieres (*Clin. Ophtal.,* viii, 1) makes the point in these cases, a point which we believe should receive fitting recognition in the compensation awards in comparablé civil cases, that the aphakic eye is entitled to more compensation than the non-aphakic eye with the same amount of vision in that it has lost the two important functions of accommodation and of binocular vision. He would award 5 per cent. additional for the loss of each of these functions, as, for example, in traumatic cataract, where 10 per cent. would be added to the amount provided by law as compensation for the loss of vision.

Lister (*Lancet*, July 20, 1918), discussing the gross pathological changes which take place in the vitreous in penetrating injuries of the eyes, has been struck by the extraordinary variety of changes encountered. He notes that in some the track of the foreign body is clearly defined, either by blood, by pus, or by a fibrous band, or, again, the whole vitreous, more or less hemorrhagic and infiltrated, may be found shrunk up around the track, but remaining attached (or as it were "pegged out") to the retina at a point at which the foreign body struck.

The foreign body, by penetrating the vascular coats of the eye from without or striking the retina and choroid within, often causes a hemorrhage to take place at one or both spots. Such a hemorrhage may merely follow the track of the foreign body, but often it is much more widespread and occurs in fans which correspond with no known structure of, or lymph channels in, the vitreous, which fans may be seen with the ophthalmoscope. Just as a bullet when passing through a limb causes splits in the muscles and fasciæ radiating from its track, into which blood and infective material will find their way, so it would seem a foreign body passing through the jelly-like vitreous may split this body in various planes into which blood and, at a later date, infective material may also spread. This seems a rational explanation for the widespread fans and planes of hemorrhage and fibrous tissue that are met with, which do not correspond with any known lymph passages in the vitreous.

The vitreous, as we have seen, becomes adherent to the retina at the point where a foreign body strikes; yet allowing for rebounding of a foreign body more than once or twice, or the possibility of more than one or two foreign bodies being present, we come across many specimens where the vitreous has been pegged out at too many spots to be accounted for by either of these causes. Hemorrhages from the retina which burst through the hyaloid into the vitreous will doubtless be a cause of adhesion between the two structures. One of Lister's specimens shows a conical hemorrhage tip to a vitreous adhesion, which supports such a view. The hemorrhage being only at the point of the adhesion, it is probable the blood came from the retina.

It would seem probable that when rifts of the vitreous caused by the penetration of a foreign body reach the retina, either blood may follow up along the rift or a new hemorrhage may start from the retina, and thus also a connecting link is formed.

Shrinking of the vitreous and absorption of the various inflammatory elements may go on till all that is left of hemorrhage and infiltration is a series of strands or fans of delicate fibrous tissue attached in front of the back of the lens, or ciliary body, and behind to the retina.

Occasionally these strands are exquisitely delicate, merely branching threads with a variable amount of pigment deposited on or in them.

Where the fibrous bands are attached to the retina they may by their shrinking exercise considerable traction, bringing about puckering or folding of the retina; or actual detachment may occur, provided sufficient exudation has not been poured out to bind together the retina, choroid, and sclerotic.

It is probable also that certain of the tears and holes which occur in the retina are due to the attachment and traction of vitreous bands.

In any case fibrous vitreous bands must be looked upon as a decided menace, and one must therefore avoid as far as possible any procedure in ophthalmic surgery which is liable to cause a vitreous hemorrhage. Thus, in removing foreign bodies from the eye, this is one of the strongest arguments for drawing at any rate the smaller magnetic particles forwards into the anterior chamber and removing them through an incision in the avascular cornea rather than withdrawing them through a new incision made in the vascular sclera and choroid, which very probably will create a fresh vitreous hemorrhage.

It is recognized, of course, that not every vitreous hemorrhage gives rise to fibrous tissue, and we may digress for a moment to discuss this point.

Fibrous tissue may follow hemorrhage both from penetrating and non-penetrating injuries. It appears to follow mild infections fairly regularly, but infection, in the ordinary acceptation of the term, is not necessary for its formation.

As Parsons has pointed out, the fixed cells of the vitreous will not by themselves produce fibrous tissue; fibroblasts from already formed connective tissue must be present, and they can pass in either from the retina or choroid after rupture in the internal limiting membrane of the retina or the hyaloid, or both.

Lister considers the delicate retinal lesions produced by the impact of foreign bodies upon the retina in their lodging or rebound as "wonderfully neat physiological experiments," through which these visible lesions can be correlated with the defects in the visual fields. Thus he finds that lesions above or below the horizontal plane cause a defect in the field out of all proportion to the local disturbance, i. e., a "distribution effect" has resulted in addition to the local defect, owing to the involvement of nerve fibers which were passing on to a more peripheral portion of the retina. The distribution defect is fan-shaped from the point corresponding with the lesion and extending towards the periphery. The nearer the lesion is to the disc the greater the blind sector, and vice versa, which agrees with the accepted distribution of the nerve fibers in the retina.

When the lesion occurs in the horizontal plane there is no "distribution defect," but the loss of the field is limited to the area corresponding with the lesion, as would be expected, for the fibers supplying the retina in the horizontal line arch around from the disc to their destination, and therefore these lesions would involve the nerve fibers only at their termination.

As an example Lister cites a case when a foreign body bounded twice on the retina. The defect in the field was two scotomata corresponding with the two lesions of the retina with no distribution defect or peripheral loss.

These sector defects following bruising of the retina are strikingly similar to the sector defects in the field following solitary patches of choroiditis described and worked out with such care by Hepburn, and which are probably due to an involvement of the nerve fibers in the inflammatory process as they pass over the patch of choroiditis rather than to any irregularity in the distribution of the choroidal vessels. Lister describes a most interesting case of complete "ring field," the result of the penetration of the cornea, iris, lens and vitreous by a minute particle which came to rest on the optic disc. The lesions produced were an adherent leucoma, a hole in the iris, an opaque track through the lens from which a delicate fibrous band extended through the vitreous to the mass of inflammatory tissue covering the disc and its immediate neighborhood. The presence of the foreign body on the disc was proven by radiogram. The rest of the fundus was normal.

The absorbing fact is that this lesion caused a nearly circular ring field; that is to say, a very large central defect, and considerable peripheral contraction, between which lay a nearly circular band in which vision was retained.

If the nerve fibers in the outer third of the disc supply the macular area, and the most peripheral fibers on the disc supply the retina immediately around, while these in the center are the long distance fibers which supply the periphery of the retina, then the fibers in the intermediate horseshoe zone on the disc must pass to that portion of the retina corresponding with this "ring field." It would have been almost unbelievable that a complete ring field could have been left, yet it has to be accepted as fact, for the field was taken most carefully on two separate occasions at an interval of several weeks, and the two fields were practically identical. This case suggests to Lister that the nerve fibers which are in association with the various concentric zones of the retina, and which will be distributed to the corresponding zones in the appropriate superior and inferior calcarine areas of the occipital lobes, are arranged in definite zones in the optic nerve. He further adduces this case to explain the concentric defects in the field which have been attributed to, but not definitely proven to be, the result of disease of the optic nerve, such as retrobulbar neuritis (e. g., Hancock's case of ring scotoma following lightning stroke) and believes, as well, that it may furnish the clue to the cause of certain diseases associated with concentric defects of the field such as retinitis pigmentosa.

Kuhnt (*Zeit. f. Augenheilk.*, 1916, XXXVI, I) treats by plastic operations on the eyeball itself those particular cases in which, without perforation of the eye itself, large parts of the cornea or anterior sclera have been lost on account of external violence, corrosion or ulceration. These heal much quicker under operative therapy while they are, for the most part, no longer in danger of perforation. Pain and secondary inflammation in the anterior area disappear almost immediately or can be easily allayed. The slight operation consists in carefully cleansing the defect, removing all particles or shreds of tissue with curette and then transplanting on the carefully prepared wound surface conjunctiva which is histogenetically closely related.

A pedunculated flap, with the pedicle above should be chosen for all deep and peripherally situated defects; for central defects a flap with double pedicle is indicated.

The flap is taken from the conjunctiva of the eyeball by means of two incisions close to and parallel with the limbus. In gauging the size of the flap it should be remembered that this elastic tissue, especially when disconnected from its surroundings and in young individuals will shrink at least one-third in all dimensions. Subconjunctival tissue should not be removed with the flap, which is placed in position by spreading it out well and pressing the wound surface of the flap gently and for some time against the thoroughly cleansed floor of the defect.

When the tissue loss is centrally situated it is necessary to secure the double pedunculated flap (which is taken from the outer side of the eyeball) in place with one or two sutures with the upper pedicle under slight tension. The flap will heal into place with almost absolute certainty, in about 6 to 8 days. The spot from which the conjunctiva was taken is covered during the first few days with a membrane similar to that in diphtheria. This soon disappears and is followed by rapid epithelialization. The transplantation of the flap will never cause disturbance of circulation or unfavorably influence the other parts of the cornea or sclera.

It should be mentioned as an advantage of this conjunctivo-kerato plastic that even extensive tissue defects extending down to Descemet's membrane can be quickly filled up and evince no tendency to ectasia with its well known destructive consequences. The resultant scar also shows surprisingly little opacity. The flap, after filling out the defect, atrophies gradually so that later frequently only a thin, scarcely visible membrane remains.

If for any reason a flap from the scleral conjunctiva cannot be formed, transplantation without pedicle from the other eye or from another individual may be resorted to with equally good result.

Tissue loss in the anterior sclera is treated in the same way except that the conjunctival covering is not used in form of a flap but merely with lateral displacement. (Conjunctivo-scleroplastic.)

If the defect of the cornea comprises its whole thickness, but is small, the same method may be employed by taking conjunctiva with episcleral tissue. It does not, however, assure the same measure of success. In larger defects the flap sooner or later becomes distended, loses its elasticity, has a glassy appearance and protrudes in the form of a staphyloma. The direct and constant pressure on the wound surface of the fluid in the anterior chamber evidently hinders the formation of a strong tissue layer capable of resistance. In these cases the author found it necessary to protect the conjunctiva in the defect against the action of the fluid in the anterior chamber by forming a substratum of living tissue. For this purpose he first thoroughly removed the epithelium from the adjacent cornea and then formed a thin flap which was twisted into the defect. After that the kerato-plastic conjunctival flap with its episcleral tissue was spread over the defect and fixed. The results were satisfactory, inasmuch as a resistant scar was gained and staphylomatous protrusion with its secondary consequences avoided.

In case one has cornea at his disposal from an eye which is to be enucleated or exenterated, this too may be used. One must, of course, provide for as broad an adhering surface as possible by smoothing off the edges of the defect, if need be with galvanocaustic wire. One should also take care that the intraocular pressure be and remain low during the time of healing. This may make it necessary to perform simultaneously or a few days later sclerectomy according to Lagrange or trepanation according to Elliot with peripheral or complete iridectomy. The conjunctival flap to be placed over the cornea and transplant should be chosen as broad as possible and should be firmly and securely attached to the opposite limbus with sutures.

Healing takes place promptly. The covering gained is usually lasting and sufficient. The same method of procedure may be employed for staphylomata of the cornea, even those of long standing, and also for circumscribed kerectasias.

In defects of the whole thickness of the sclera a covering with sufficient power of resistance cannot be gained by the use of conjunctiva alone, or even conjunctiva with subconjunctival tissue. Here too it must be padded underneath with other tissue. The most evident thing to do is to use adjacent sclera after splitting it, since even a very thin layer over the defect is sufficient to form with the conjunctiva a resistant covering. It is easier and gives better success to use a strip from a tendon of the nearest rectus muscle, if the defect is between the ridge of insertion and the cornea or between two muscles. The tendon is laid perfectly bare, a flat tendon hook is introduced beneath it and a suitable flap is then excised from the middle portion with its base at the ridge of insertion. This is then bent forward, or forward and upward, or downward and sutured to the edges of the defect with a few thin catgut threads. The spot from which the flap was taken is closed by suture. The defect is then covered with conjunctiva. Also, transplantation of whole thicknesses of sclera or single lamellæ from simultaneously enucleated eyeballs may be employed; conjunctiva is then drawn over later. Judging by his other experiences, Kuhnt thinks that a strip of fascia lata should be suitable for the covering of scleral defects and is inclined to attempt the padding of conjunctiva with it. He also advises the use of a strip of fascia lata in all cases in which not only the sclera is lacerated but also where a tendon of one of the recti is torn off or severed. After suturing the scleral wound the fascia should be carefully sutured with catgut to the remains of muscles or tendon and to the sclera.

III. THE PROBLEM OF ENUCLEATION.

Probably as much bloody human sacrifice is still offered unwittingly at the twin altars of Ignorance and Fear as in the rarest days of Baal and Moloch. The early months of the war saw the climax of these unwilling surgical offerings and the few ophthalmologists in active military work at that time can attest that no small part of the sacrificial tithes were ophthalmic. The general surgeons who bore the overwhelming brunt of those unspeakably stressful days before the natural cleavage into specialist lines occurred, were ignorant of ophthalmic procedure, fearful of the results of even trivial eye injuries, were worked and worried almost literally to death and it should excite no wonder that these devoted men sacrificed many eyes unnecessarily. That general surgeons should have persisted later in the war in performing early excisions of badly wounded eyes and often of both eyes as was done not rarely despite the unnoted protests of ophthalmic surgeons, should provoke such general censure as to lead to the omission of the operation of enucleation from the general surgical curriculum and to its performance by trained ophthalmic surgeons alone.

F. de Lapersonne (*Arch. d'Ophtal.,* p. 449, Vol. 35, No. 11), Dianoux (*La Clin. Ophtal.,* Feb., 1917) and Angelucci (*Archiv. di Ottal.,* 1917, p. 159) all protested against the freely practised enucleation which was often done within twenty-four or forty-eight hours after injury. In these operations the conjunctiva was frequently grossly excised or mutilated, foreign bodies and splinters of bone left in the orbital tissue where they induced interminable suppuration, and vital parts of the lids excised with a surgical largess which made the ultimate wearing of a prothesis almost impossible. De Lapersonne cites a number of cases which were brought in after double enucleation, all of which were operated on either on the day they were wounded or within forty-eight hours, some of them having been attended to in a large ambulance at the front, the staff of which consisted of seventeen surgeons without a single oculist.

There is no excuse for this undue haste, as ocular hemorrhage is never dangerous, panophthalmitis does not set in immediately, and the spreading of an infection to the meninges is certainly not prevented by a hasty enucleation; on the contrary, it is a fact that in deep wounds of the orbit with escape of cephalo-rachidian fluid enucleation is disastrous.

Not rarely some degree of sight has been saved to eyes which seemed lost. If blindness is unavoidable it is much better that the wounded should be prepared for their loss gradually, and not subjected to such a terrible privation at a time when their moral and physical conditions are at their worst. On the other hand, it may happen that unlooked for improvement may set in after waiting a few days, a case reported by Brunetiere and Amalric illustrating the point (*La Clin. Ophtal.,* May, 1917): A fragment of shell penetrated the lids over the caruncle causing a scleral wound 9x10 mm. in area and such persistent bleeding that a scleral suture was demanded. Vision was reduced to uncertain appreciation of hand movement but despite this extensive injury, which would certainly have led to enucleation in less experienced hands, a final vision of 4/10 was obtained.

During the war some controversy arose over the relative merits of enucleation and evisceration but the late comparative symptomatic results reported by Dor (*Clin. Ophtal.,* viii, 4) apparently settle the question decisively in favor of enucleation. Dor found that 41 out of 63 soldiers who had suffered removal of one eye (23 by enucleation and 40 by evisceration) had no subsequent trouble whatever. Twenty-two complained of lachrymation, photophobia, periorbital pain and accommodative asthenopia and the fact that 21 of the 22 had had ocular evisceration manifestly proves the superiority of enucleation. Tender and irritable stumps have been noted after evisceration by other observers and Monbrun (*Archiv. d'Ophtal.,* xxxv, 3) details a peculiar case where continuous burning pain began on the side of the face and head on which a partial resection of one eye had been made, leaving a stump of the posterior pole. These pains gradually became unbearable and were associated with a somewhat disturbed mentality, vasomotor and secretory disturbances on the affected side, in the form of constant vasodilatation, and marked overaction of the sweat glands. This condition was ascribed to a true sympathetic neuritis of the sympathetic fibers entering the ciliary ganglion and of the ciliary nerves, although excision of the ocular stump with the ophthalmic artery and with the sympathetic chains gave no relief.

The comparative merits of simple enucleation and of the scleral frill operation without opening the meningeal sheath of the optic nerve, designed by Lister as a preventive measure against possible extension of infection to the cerebral meninges and venous sinuses, are less easily determined. The risk of life incurred by enucleation is about 1 in 4000 and while simple enucleation in the presence of traumatic suppurative panophthalmitis may theoretically increase this risk it can do so to no great extent. The aim of modern surgery, however, is to eliminate every possible risk and in this sense Lister's operation should be the operation of election in the face of suppuration. The greatest care must be taken, however, in all incomplete operations of this sort to remove every trace of retina and choroid from the sclera, in view of the well known tendency of retained uvea to set up irritative changes of a sympathetic type in the remaining eye.

The indications for enucleation. All means should be employed to save traumatized eyeballs, even if sightless, and the operation of enucleation, which has become the most frequent eye operation in military surgery, should not be practised without the assurance, gained from fitting experience, that the retention of the injured eye will menace the fellow eye, will perhaps endanger life or will lead to a blind and painful stump. It is safe to say that the greater the skill and experience the fewer will be the enucleations, although it is recognized in making this general statement, that operative conservatism should not be carried to the extreme of temporizing with painful and irritable eyes for long periods after injury, or with eyes which are obviously on the way to atrophy or to exudative iridocyclitis.

In general, where an eye has been too badly injured to be saved, where large amounts of vitreous have been lost, where only remnants of eyes remain, in traumatic iridocyclitis without light perception and in all conditions where, after vigorous and sufficiently prolonged attempts to save the eye sympathetic ophthalmitis is to be feared, enucleation should be done. Weekers (*Archiv. med. Belges*, March, 1917) justly declares that where the wounded are placed at once in hospitals where the discipline of asepsis reigns, there is no cause to remove an eye for the sole reason of warding off a sympathetic ophthalmitis. There is no hurry, for one can wait a few days at least, without danger, unless one's hand is forced by pain and irritation.

Large openings into the vitreous chamber with a loss of vitreous up to fully 20 per cent. of its bulk may be closed by suture and conjunctival covering and, if not infected, not seldom yield surprising results in terms of practical vision. Active infection does not necessarily mean enucleation, for the curative value of massive subconjunctival injections of cyanid of mercury, especially when used early, is well known and should be even more generally employed than it is, together with the internal use of calomel and salicylates when the injury involves the ciliary region.

Where both eyes are blind or are ruptured they should be left, save only in the presence of panophthalmitis. If they are both blind and contain foreign bodies, so long as these bodies have not led to local inflammation and persistent discomfort, they need not be extracted. Where both eyes are blind and painful and contain no foreign bodies, the removal of which might restore comfort, the massive injection of cyanid of mercury often relieves pain, assists in resolution of the inflammatory process and hastens cicatrization. If this measure, combined with heavy dosage with salicylates and the relief of every possible general source of low grade infection fails, it is better to attempt opticociliary resection before finally being forced to enucleate, a finality which is exceedingly rare under such conditions.

Judging from a considerable experience, enucleation under local anesthesia is to be commended without reserve except with highly nervous men and in the presence of orbital suppuration. Its complete painlessness even when used with greatly injected eyes, the lack of shock and the relative absence of bleeding all commend it, although it is wiser to use general anesthesia when fat implantation is to be employed in place of the more common implantation into Tenon's capsule of glass spheres or of the bone or cartilage protheses of Lapersonne and others.

Collins (Doyne Lecture) suggests that, aside from the usual operations for paralytic or traumatic ptosis after enucleation, a useful trick is to affix to the glass eye just above the limbus a small projecting ledge of clear glass in order to catch and hold up the upper lid.

IV. SYMPATHETIC OPHTHALMITIS.

Our recent conceptions of the origin of sympathetic ophthalmitis are in process of revision as a result of the altogether unexpected rarity of its appearance among the tens of thousands of eye injuries which occurred during the late war.

A survey of the literature of this subject up to the outbreak of the war shows how deeply our views had been tinctured by the incorrect observations and false deductions of the German observers in the war of 1870, who reported the occurrence of sympathetic ophthalmitis in 55 per cent. of the cases of ocular injuries, statistics which indicated that the sound eye was damaged by the injured one in every second case of injury. The events of this later war, however, proved the inaccuracy of the data and led to their further examination, as a result of which Dimmer (*Klin. Monatsb. f. Augenh.,* Vol. 57, p. 257), Weekers (*Ann. d'Ocul.*, cliv, 4) and others concluded that the Germans had included in their statistics all the cases of traumatic reflex neurosis and all cases of functional disturbances in the uninjured eye, such as lachrymation, photophobia and asthenopia. A careful study of the histories of all the cases reported shows that not a single case of undoubted sympathetic ophthalmitis was recorded, although sympathetic irritations were observed repeatedly.

It will be several years yet before the exact number of cases of sympathetic ophthalmitis referable to this war can be tabulated and studied and more light shed upon its relation to intraocular foreign bodies, to the injury of uveal tissue and to infection. Nearly every theory of causation advanced to date seems untenable when applied to the enormous number and diversity of eye wounds furnished by this war and the rarity of this peculiar inflammation. Surely if the specific anaphylactic effect of uveal tissue were the potent factor claimed by its proponents; if infection of some specific microbial nature holds the rôle; if remote infectious processes in the teeth, gums, tonsils, intestines or genito-urinary tract supply the unknown *materies morbi;* or if autotoxic chemical poisons of intestinal elaboration furnish this irritative agent, such factors would have been active in the production of so characteristic a condition in numbers far greater than the score or two of typical cases which have been reported.

Harbridge (*Amer. Jour. Ophthal.,* April, 1919, p. 270), speculating upon the origins of sympathetic ophthalmitis, says: "It is difficult to believe that the causative agent of sympathetic iridocyclitis is always resident in the injured eye alone, and that it is the sole etiologic factor to be considered in accounting for the changes in its fellow. If it were, how can those cases be explained in which useful vision is retained in the originally injured eye, and yet the sympathizing eye is lost. It seems reasonable to believe that, if the agent is virulent enough to destroy the sympathizing eye, surely it would produce a like result in the one originally involved, especially in view of the fact that its uveal tissue has already been damaged.

"These clinical observations are of interest in connection with certain histologic knowledge. Previous to the severity of an attack of sympathetic iridocyclitis more or less discrete granular elevations in the choroid have been observed. In destroyed eyes, which have been enucleated and examined microscopically the uveal tract shows isolated accumulations or elevated formations of proliferating epitheloid cells. The various stages of progression, and more or less isolation, of these nodular formations is strong evidence of their independent development, the agent being deposited at these several points at varying intervals.

"If this is correct, the natural medium of transmission would be the blood current. The agent may be in part or wholly derived from the primary injured eye, yet, it seems good reasoning to believe, especially in view of the above clinical experience, that other foci of infection are not only contributing factors, but may be the essential source, by reason of the ease with which the blood stream can convey these agents from one part to another.

"The intimate association of sympathetic iridocyclitis with the uveal tract, and the almost uniform accompanying penetrating wound of the eye capsule, arouses interest in contemplating the many perforating injuries to the globe which are never followed by any evidence of this malady. The vast majority of penetrating wounds heal and remain quiet, or at least they do not inaugurate inflammatory changes in the fellow eye. It is inconceivable to believe that they are all aseptic. Doubtless in many instances, likely the majority, the bacteria that find access to the parts are benign, or at least of such a strain as do not possess any special affinity for uveal tissue. If they were immediately virulent at the time of injury prompt destruction of the injured eye would ensue.

"If the proper bacteria gain entrance at the time of injury, clinical evidence indicates that certain preparation must take place, as they do not become active for several weeks, and in some reported instances, years. This view is quite in accord with Rosenow's work. Certain strains of bacteria, especially streptococci, have a selective tissue affinity, or they are able to develop this affinity by growing in certain tissue, as, for example, injured uveal tissue.

"It is quite in keeping with the clinical course of sympathetic iridocyclitis to say that streptococci, or, perchance, some other microorganism, infect the injured uveal tissue of one eye, at the time of injury or subsequently, from some other body focus; and after a certain interval they develop an enhanced ability to attack and destroy similar tissue in the other eye. The time interval is just as much in favor of this as it is in favor of the development of tissue sensitiveness. In view of reported cases of sympathetic iridocyclitis in eyes with intraocular growths this seems especially adaptable as an explanation, the injured uveal tissue affording the necessary cultural media, the bacteria being supplied from some endogenous source.

"The results obtained in the experimental work on anaphylaxis have all been on lower animals. The fact that sympathetic iridocyclitis is seen less frequently speaks against anaphylaxis. Surgical precautions would not affect the development of anaphylaxis in an injured eye, but would prevent bacterial destruction of tissues by removing the media suitable for bacterial growth. From the increasing number of eye injuries, and the decreasing occurrences of sympathetic iridocyclitis, possibly as a result of surgical interference, even when the globe is penetrated and tissues destroyed,—if it were anaphylaxis,—we would expect the number of cases to keep pace with the number of eye accidents, but they do not.

"A fuller understanding of the nature of sympathetic iridocyclitis demands a more searching investigation for possible related processes in other parts of the body."

A negative and practically conclusive observation made during the war has proven most important, however, as a means of elimination of possible causes of this condition no less than of serving to change our point of view. It is an established fact that a chemically inert and sterile foreign body does not of itself cause sympathetic ophthalmitis. The significance of this fact is tremendous in its relation to the military and civil treatment of eyes containing non-magnetic bodies in inaccessible positions, or foreign bodies whose removal has been neglected. Shoemaker (*Amer. Jour. Ophthal.,* Aug., 1919, p. 593) states, in this connection: "The universal teaching a few years ago made the removal of such eyes obligatory. Not to do it was then malpractice. To do it now, per se, is practice equally bad. It all hinges on the question of sympathetic ophthalmitis and I know of no disease that has so failed to make good during the war, with such unlimited opportunity, as has sympathetic ophthalmitis due to the retention of a foreign body within the eyeball."

The rarity of the condition in war injuries has been very generally ascribed to the asepsis and antisepsis which are now so generalized, to more accurate diagnosis, to the more prompt and more vigorous application of treatment, to the healthy condition of the soldier which may make him less susceptible to disease and, finally, and stressed most frequently, to early preventive enucleation.

With regard to the last of these factors it is well known that sympathetic inflammation generally appears within the first year after injury, usually after the fourth week, and most frequently between the sixth and the twelfth week. Dimmer comments that if it could be shown in a very large number of war injuries that sympathetic ophthalmia was observed almost without exception where the injured eye was removed relatively late, i. e., after the sixth week; and if the number of sympathetic ophthalmias is about the same as that which we ordinarily find after injuries or eye diseases which are prone to cause sympathetic ophthalmia, then we would have to conclude: that the marked reduction in the number of sympathetic ophthalmias in war injuries is due to timely enucleation, a fact that would deserve the widest publication. But that enucleation does not entirely guard against this sequel is shown by Schiek (Heidelberg Ophthal. Congress, 1916) who details seven cases which have followed preventive enucleation after shot wounds and another which followed optico-ciliary resection. The wounded eye was enucleated in four cases at a time when the other eye was apparently completely healthy, and in the other three the removal followed the outbreak of sympathetic trouble. The course of all these cases was benign. The conclusion has been reached very generally, however, that the prognosis is notably better in those cases where enucleation has been performed before the appearance of the sympathizing inflammation.

Cousins (*Arch. d'Ophtal.,* Dec., 1916) calls attention to the not infrequent cases of sympathetic irritation which are produced in the uninjured eye in consequence of injury to its fellow, with the idea of carefully differentiating them from true sympathetic ophthalmitis. The symptoms in the wounded eye are pain, tenderness on pressure, lachrymation, conjunctival injection and, less constantly, photophobia. These persist even after cicatrization is complete although in varying degree and with occasional exacerbations. The symptoms noted in the unwounded eye resemble those in the injured although they are less severe and appear from 36 hours to ten days after the injury. Cousins considers photophobia, tearing, discomfort in close work and reduction of the visual acuity from 1/10 to 1/2 as characteristic. Ophthalmoscopic signs are negative. These symptoms are not relieved by medical treatment of any nature and finally demand enucleation, which is followed by prompt symptomatic relief, although the visual recovery may be slow.

Arnold Lawson (*Brit. Jour. Ophthal.,* Oct., 1917, p. 640) summarized the warning signs which will notify the surgeon that he is taking undue risks as follows:

"1. Protracted and intractable cyclitis or general uveitis, which goes on for week after week in spite of treatment.

2. The gradual supervention of an increasing lowering of the intraocular tension, which is always accompanied by progressive failure of sight.

3. Continual photophobia and sympathetic neurosis affecting the other eye.

4. The condition of the blood count" in that a mononuclear leuco-

cytosis appears although Gifford declares this last sign to be evident in all chronic ocular inflammations. "Perhaps the most important of these signs is the increasing reduction of the intraocular tension. It is the most unfavorable sign we can have as regards the vision," and when once the eye has become markedly minus in tension in the fellow eye, there can be no doubt of the prudence of removal.

No great value can be gained by a statistical study of the cases of sympathetic ophthalmitis of military origin reported to date. Those cases given in detail have much of interest and the reader is advised to consult the originals for this detail. The most extensive communication on the subject that has yet appeared is that of Morax (*Ann. d'Ocul.*, cliv, Dec., 1917; abstracted in detail in the *British Jour. Ophthal.,* Aug., 1918, p. 444). This valuable paper, which largely fulfils Dimmer's requirements, is a compilation of the work done by the foremost ophthalmologists doing military work in France, the list including the names of Aubineau, Cantonnet, Chaillous, Chevallereau, Coutela, Dor, Dupuy-Dutemps, Frenkel, Kalt, Galezowski, Legrange, de Lapersonne, Petit, Rochon-Duvigneaud, Rollet, vanSchevensteen, Valude, Poulard and others.

Character of the initial wound. In all cases, except one in which sympathetic ophthalmitis came on after iridocyclitis following perforation of a corneal ulcer, there had been a penetrating wound of the cornea or anterior part of the sclera, usually (31 cases) penetration by fragment of bullet, shrapnel or bomb, or in a small number of cases (4) accidental puncture, or in 3 cases (2 cataract, 1 iridectomy) operative interference. In a good many of the cases iris or ciliary body prolapse was noted, incarceration 14 times at least, while an intraocular foreign body was present in 10 of the 39 cases. Sympathetic ophthalmitis coming on after intervention may be due to the original injury rather than to the operation, but in one case of contusion the operation for traumatic cataract was followed by sympathetic ophthalmitis. *No pure case of contusion was followed by sympathetic inflammation,* which would support the usual theory of infection and negative the anaphylactic theory of Elschnig.

Rôle of the operations practised before the appearance of the sympathetic inflammation. Interventions undertaken with the object of preventing immediate infection or sympathetic infection were conjunctival flaps, resection of iris, etc., or evisceration and enucleation. The accompanying table shows the number of days after the trauma when the operation was done and the number of days after operation before sympathetic ophthalmia appeared.

SYMPATHETIC OPHTHALMITIS

Operation.	Interval after trauma.	Time before sympathetic ophthalmia appeared.
Conjunctival flap	28 days	50 days
Conjunctival flap	2 months	9 days
Conjunctival flap	1 month	?
Conjunctival flap	27 days	2 days
Resection of iris	1 month	31 days
Resection of iris	24 hours	32 days
Ablation ant. segment	48 days	3 months
Evisceration	57 days	1 month
Evisceration	4 days	1 month
Enucleation	32 days	12 days
Enucleation	14 days	22 days
Enucleation	15-20 days	1 month
Enucleation	58 days	2 days
Enucleation	33 days	10 days
Enucleation	39 days	16 days
Enucleation	69 days	41 days
Enucleation	46 days	3 days
Enucleation	45 days	17 days
Enucleation	40 days	3 months
Enucleation	31 days	2 days

This table shows that one must fear sympathetic ophthalmia in the first three months, especially in the second month, but after the third month, it is exceptional. *Enucleation within the first two weeks will prevent the development of sympathetic ophthalmia in most cases.* Morax believes that *evisceration of the globe ought to be rejected* and speaks of the development of sympathetic ophthalmia after evisceration in a case of Kalts. No signs or symptoms seem to aid in the prognosis of an individual case. Usually the eye remains irritable and tender with photophobia, but not all such are dangerous, for many fail to show the characteristic uveal changes. The end result may be a cure in some weeks or even a year. On the other hand, there may be great destruction of the globe with lessened or increased tension and atrophy. In the series reported, benign cases were predominant, showing the following end results:

Blindness or practical blindness in twelve cases, vision 0.1 in one case, suicide in one case. Vision of 0.5 to 1 in twenty cases, vision of 0.3 to 0.4 in five cases. Fourteen ended badly and the remaining twenty-five ended favorably.

Probably all observers expected an increase in sympathetic ophthalmia as a result of the many injuries to eyes during the war. Lapersonne saw one in military service and two in civil practice, as did Sexe. Sourdille, however, did not see a single case in more than three thousand military wounded, but five in civil practice, three of which resulted in blindness.

At the Lariboisiere Ophthalmic Centre, from September, 1914, to November 23, 1917, there had been seen 6,265 military cases with only one sympathetic, and 23,832 civil cases, with five cases of the disease; one of which ended in blindness, three in full vision and one in 5/10 vision: as a result of mercurial injections and novarsenobenzol intravenously combined with enucleation. All five had the first eye examined microscopically and the characteristic picture confirmed, one case of injury with copper fragment developing sympathetic disease twenty-five months after the injury.

Elschnig (Graefe's *Archiv. f. Ophth.*, Vol. 92, p. 505) reports 5 cases, in one of which the sympathetic affection manifested itself 3 days after evisceration and in another 14 days after enucleation of the eye primarily affected. Cases are reported by Sachs, Krusius, and Birch-Hirschfeld (*Klin. Monatsbl. f. Augenheilk.*, p. 257, 1916), the last-named describing an injury by a splinter of a bomb, 18 days before the case came to the hospital. The eye showed a mild iridocyclitis: few precipitates on Descemet's membrane; cataract; globe slightly tender to the touch; and movements visible directly in front of the eye. Enucleation was resorted to at once. Two days later, the fellow eye showed typical signs of sympathetic disease. M. Sachs made an oral report of a case. The eye was enucleated late, and shortly after the enucleation, typical sympathetic disease appeared in the fellow eye. The statements of Krusius are too general to permit of any definite conclusions.

Wessely notes (*Münch. med. Woch.*, 1917, p. 1621) that up to the time of his report but 8 cases had been seen in the German army. Angelucci (*Archiv. di Ottal.*, 1917, p. 159) describes his sole case; that of a young officer whose left eye was enucleated two days after the wound. After the third week became aware of the first symptoms of visual deficiency, especially in the upper sector of the visual field. While at home on leave of absence there was an alternation of deterioration and improvement; after four months he could hardly find his way about. He came to the clinic with the stump extremely painful beneath the glass eye. After the iridochoroidal symptoms had almost disappeared from the right eye, the visual field and the ophthalmoscopic appearance revealed a classic process of retrobulbar neuritis, the papilla was whitish and slightly obscured, the arterial vessels very slender, and some of the veins markedly congested. After urgent removal of the painful cicatricial stump, and under endovenous injections of sublimat in one per cent. solution, iodid of arsenic and of strychnin, the vision rose in a short time to 7/10.

Schevensteen (*Ann. d'Ocul.*, Vol. 155, p. 392) cites the history of a patient, in war August 19, 1917, who was discharged October 18, 1917, with a complete traumatic cataract. Vision of the other eye was normal. On November 21st the cataract was extracted, the patient, however, squeezed his lids, causing a hernia of the iris, which was excised. The anterior chamber filled with blood which showed little tendency to absorb, but on December 15th the eye was normal. January 9th the other eye became painful and in two days was injected, with photophobia, Descemet's deposits, tension slightly minus and vision 0.4. On January 14th, the symptoms persisting, the eye was enucleated. January 31st some papillitis, novarsenobenzol was given twice. Improvement was gradual until April 1, 1918, when cured. Microscopic examination of the enucleated eye showed incarceration of the iris in the corneal wound, with infection and the uveal changes characteristic of sympathetic ophthalmia.

Poulard claims enucleation did not prevent sympathetic ophthalmia developing four months later but his case is so unusual and the diagnosis so uncertain that a brief review is worth while.

The man was wounded on the right eye by a piece of shell, April 30, 1915, May 11th, it was painful, soft, with hyphema, and, by radiography, an intraocular foreign body was located June 9, enucleation was done. At the end of September the sight of the left eye, which had kept perfect, began to fail, and he consulted Poulard. On October 1, vision was one-fourth, much floating vitreous opacity, slight signs of iritis present and the fundus showed peripheral choroiditis with small brownish spots. On October 12th, more vitreous opacity, iris markedly affected, with pupillary exudates and synechiæ, two small spots of corneal infiltration, tension normal, vision equal one-fifth. There was steady progress of iris infiltration with pupillary exudate, the vision lost, the eyeball became small and atrophic. There was no report of the general examination details or pathologic eye findings. The eye was quiet for four months and then in the next two months, the sight was destroyed.

McKee (*Canadian Med. Assocn. Jour.*, Feb., 1918, p. 108) saw two cases of sympathetic ophthalmitis among about 3000 ophthalmic cases, but gives no details. Moore (*Lancet,* Feb. 22, 1919, p. 300) reports a case of sympathetic ophthalmitis with fundus changes, developing during the progress of the disease and visible throughout the course.

The man had a penetrating wound of the right eye, and presented himself with a prolapse of the iris and ciliary body. The prolapse was removed on the seventh day after the wound and the eye was taken out a fortnight later.

The first sign of anything amiss with the left eye occurred 20 days after enucleation of the right, in the form of slight mistiness. Two days later there was slight tenderness on palpation, and a fine deep haze was present in the lower part of the cornea. The fundus was normal, but there was some distention of veins. The appearance of the central part, around the stump of the optic nerve, caused the author to suspect that uvea had been left behind; but it was found that the eye had been cleanly removed and there was no uveal pigment left.

Six weeks after the original wound there was a fresh crop of keratitis punctata spots. The blood count was normal. Radiography did not reveal any foreign body; Wassermann negative. There was a marked increase in the keratitis punctata, but later that disappeared, though it subsequently reappeared. Five doses of neosalvarsan were given.

Doyne reports an interesting case resembling sympathetic ophthalmitis where a fragment of shell struck a man's rifle while he was sighting through a loop-hole and richocheted into his left eye. A macula of the left cornea together with a small rosette-like opacity in the lens marked the course of the foreign body, and set into the margin of the disc a metallic-like particle appeared, about half the size of the papilla. Eight weeks later frank papilledema was apparent in the other eye.

Aside from the consistency with which preventive enucleation is urged in all quarters, an attitude freely justified by Morax statistics given above, no especial therapeutic novelties in the treatment of sympathetic ophthalmitis have appeared during the war. The rigorous elimination of all associated infections in the teeth, tonsils, nasal sinuses, intestines and genito-urinary tract is being urged with increasing insistency; highly acid and toxic stools must be overcome by dietary regulation, thorough catharsis and colon irrigations; and pilocarpine sweats, mercurial inunctions (much employed by the Germans but considered by the British to be without influence) and the early and high dosage of salicylates by the method which has afforded Gifford such brilliant results are still the medical sheet-anchors. It is now clearly recognized that injuries which involve the iris and ciliary region must be watched with the greatest solicitude and that from the first possible moment following the injury every means of preventing secondary infection must be adopted. Free irrigation of the eye and careful mechanical cleansing, followed by the application of tincture of iodine to the edges of all wounds; the closure of all open wounds by suture or conjunctival coverings; the lavish employment of 1-3000 bichloride of mercury ointment; and the early use of massive injections of cyanide of mercury beneath the conjunctiva, to modify beginning infection, are all invaluable local measures to that end.

V. INJURIES OF THE ORBITS AND ADNEXA.

It is mainly by means of associated orbital injuries that ocular wounds become matters of general importance and gravity. When such injuries occur, the eye lesions are likely to be more or less overshadowed by the problems which arise from breaching of the cranial fossæ, from injury to the sinuses and great vessels which cluster near the orbital apices, from the consequences of the wide-spread destruction of the bony barriers between orbits and the nasal fossæ and, finally, from the hideous mutilations and extreme tissue defects which result so frequently from grossly lacerating shell fragments and oblique bullet perforations.

The anatomical position of the eyes in the head whereby they are shielded so effectually against ordinary trauma, in the case of the highly energized missiles of battle, is converted into a menace to the sight. The orbital buttresses no longer serve as protective bulwarks but are crushed in under the impact of bullet and shell fragments and do irremediable damage as secondary missiles, not alone to the eyes, but too often to the brain and the great nasal cavities.

Orbital injuries may be grouped into (a) injuries of the bony orbital wall and of the contents of the orbit and (b) injuries of the bony orbital wall and of the adjacent extraorbital structures. This classification, like most classifications of military wounds of the eyes; is clearly empirical, for in the majority of orbital injuries the damages are complex and often involve the bony orbit, its contents, the structures immediately contiguous and remote structures as well.

The general considerations of orbital injuries are given concisely under the heading of *Wounds of the Orbit,* in Vol. X, of this *Encyclopedia,* pp. 7731-7742, which should be reviewed in this connection.

(A) Injuries of the orbital wall associated with damage to the orbital contents are chiefly of interest through the indirect, and to a less degree, the direct concussion and contusion borne by the ocular coats and intraocular contents as the result of transmission of the energy of impact sustained by the bony orbit, to the globe and its contents, via the orbital fat. This absorbing subject has been treated in detail under the head of *Ocular Injuries from Concussion and Contusion.* Injuries to the optic nerve are also discussed in detail under both of the references just cited and the reader is further referred to the works of Lagrange (*Les Fractures de l'Orbite par Projectiles de Guerre* and the no less admirable *Atlas d'Ophtalmoscopie de Guerre*) for striking pictorial evidence of the bewildering diversity and the gravity of these lesions. The exceedingly fatal wounds of the orbito-naso-cerebral type are also considered under cerebral injuries.

Lagrange found 609 cases of orbital injuries among 2554 war injuries, showing a very large preponderance of orbital fractures. Of these head cases, 397 i. e., 65 per cent. were healed with conservation of the globe; 212, 34.5 per cent., with its destruction; 105, or 17.2 per cent., did not have any ocular lesion, whereas, in 292, or 47.9 per cent., the eye was injured or destroyed.

The ocular lesions noted among the 292 cases were atrophic and pigmented chorioretinitis, 94; chorioretinitis proliferans, 45; detachment of the retina, 40; vitreous hemorrhage, 31; optic atrophy, 29; optic neuritis, 22; section of optic nerve, 12; laceration of optic nerve, 4; subluxation of the lens, 2; cataract, 7; corneal lesions alone, 6. In addition, the adjoining nasal sinuses and the brain were involved in 154 cases; the sensory nerves in 43, the muscles in 27, the lachrymal passages in 25 and orbital cellulitis occurred in 2.

Lagrange points out the fact that the fractures of the cranium by projectiles from firearms do not show irradiation, nor do they show fracture by contracoup, contrary to many met with in civil life, where the sphenoidal fissure, the optic canal and the structures contained therein may be indirectly affected. Fractures of the orbital vault in army surgery are always found to be direct.

Although the eyeball is preserved in about two-thirds of the cases of orbital fracture it is usually affected in such instances (a) by injury to its nerves and vessels, without involvement of the globe itself in direct injury: (b) by concussion injuries; (c) by missiles which graze the globe tangentially without rupture, but which, by forcing the eye against the orbital wall, cause damage at the point of contact with ruptures of the choroid and retina, retinal detachment and very frequent macula changes. The larger lesions are usually those produced by greater degrees of violence and are always situated on the side corresponding to the orbital fracture. The details of these conditions have already been discussed above.

Wessely (*loc. cit.*) states that about half of the cases of bilateral blindness are due to rifle shots, nearly half of which are transverse shots through both orbits. Cosmetattos reports that there were 29 cases of complete destruction of both eyes in the Greco-Turko-Bulgarian war. Oguchi found a total of 53 such cases out of 3,781 ocular injuries in the Russo-Japanese war. Statistics covering this subject and particularly defining the frequency of blindness from perforation of both orbits during the recent war are not yet available. Greenwood, however (*Amer. Jour. Ophthal.*, August, 1919, p. 580), states that the totally blinded from battle injuries will be slightly less than 100 (A.E.F.). Obviously such injuries will have run into the thousands in the British and continental armies. Genet (*Lyon Chir.*, Nov. 1, 1916), claiming that 6 per cent. of soldiers having serious eye injuries lose both eyes, while 15 per cent. lose one eye. It is remarkable that in a number of cases of this sort reported the bullet has entered one temple and emerged through the other without any loss of consciousness from so grave a trauma.

Retained orbital foreign bodies. Foreign bodies retained in the orbit, for the most part cause little damage and orbital phlegmon from this source is surprisingly seldom seen. Shrapnel apparently from its chemical composition, occasionally excites a mild inflammation, in which case, if the size and position of the missile permit, it should be extracted. Small particles lying deep in the orbit are, however, usually innocuous and should be left unless cellulitis develops, when they usually appear with the pus freed by incision or are washed out by later irrigation with saline or Dakin's solution.

There are four points of interest with regard to orbital foreign bodies: (a) the frequency with which fine fragments enter the orbit through the closed lids or the conjunctiva without discoverable wounds of entrance; (b) the amazing size of the foreign bodies which may pass through the interpalpebral fissure without wounds of the lid and which may lie concealed far back in the orbit or remain firmly lodged in the orbital wall with more or less intranasal protrusion; (c) the frequency with which missiles enter the orbit, with or without destruction of the eye, but pass through the orbit to lodge elsewhere in the face, the brain, the neck or even in the trunk and (d) the diagnostic difficulty produced by the perforation of the eye by a small foreign body which comes to rest in the orbit just outside the sclera or, just protruding from the sclera into the orbital fat.

When the characteristic symptoms of intraorbital conditions exist, such as edema of the lids, chemosis, proptosis, and fixation of the globe to any degree, and these have appeared after a projectile wound or even an uncertain injury in the neighborhood of the orbit, it is highly suggestive of a foreign body in that cavity. If stereoradiography is negative the treatment should be symptomatic and, in the case of small foreign bodies, expectant. Larger foreign bodies should be extracted at once not through the conjunctiva where, as Derby suggests, the enlargement and bruising of the wound will leave a bad scar but, rather, through an incision in the skin of the lid on a line corresponding to the orbital margin. A good incision for a free access to the orbit is on a vertical line starting from the outer extremity of the brow, extending downwards 1 cm. on the outside of the external commissure and curving toward the nose for about 2 cm. along the lower orbital margin. This incision has the double advantage of avoiding the opening of the conjunctiva and of sparing the facial nerve fibers going to the orbicularis. The orbital periosteum is then easily separated to the tip of the orbit and the finger introduced deep into the wound can feel the foreign body. If this fails the fluoroscope may be used.

The concurrence of reduced ocular tension and a scleral or corneal wound does not deny the possibility of a perforating wound of the globe with lodgement in the orbit, and in such cases, with or without tension changes, a slight proptosis may furnish the diagnostic refinement which may be lacking even with the radiogram. Cases of this sort are to be treated expectantly and where there is doubt whether the foreign body is in the vitreous, imbedded in the sclera or is just extraocular, not only is there no harm in waiting the onset of mild irritative signs before resorting to extraction, but in a considerable number of cases, no symptoms will develop and the foreign body in the scleral wall and in the orbital fat will become encysted and innocuous as is the case with the great majority of foreign bodies lodged in the orbit.

Many unusual cases of intraorbital foreign bodies have come under the observation of every military ophthalmic surgeon of experience and many such are reported. Harris describes and illustrates with a radiogram a case in which a bullet appeared to have entered by the left inner canthus, and to have passed along between the globe and the inner orbital wall until it reached the apex of the orbit. Here it turned downward, inward and forward, describing an arc of more than 180 degrees, and entered the sphenoidal sinus, wounding in its course the optic and oculo-motor nerves. Left optic atrophy resulted. The bullet was removed.

Collins (*Trans. Ophthal. Soc. U. Kingdom*, p. 292, Vol. xxxviii) reports a case where a bullet entered the left orbit and emerged below the right ear, causing a partial paralysis of the right facial nerve. The unruptured left globe had a tension of —1 and showed hemorrhage into the retina, choroid and vitreous. Later there was much pigmentation of the retina and choroid, with obvious tears below and around the disc and with corresponding scotomata in the visual field. In another case a bullet entered at the upper and outer wall of the left orbit and emerged below the right ear. Hemorrhage over and around the left optic disc appeared, with later pigmentation above and adjacent to the disc and final optic atrophy. Loss of sensation of the areas supplied by the first and second divisions of the right fifth nerve occurred but no injury to the right eye or right facial nerve was seen. In a third case a piece of shell entered the left preauricular region. The externi of both eyes and both levatores palpebrarum were paralyzed. The pupillary action was uninfluenced. The optic nerves were unaffected and near vision was Jaeger 1 and 4 respectively. A radiogram located the missile near the floor of the aqueduct of Sylvius near the nuclei of the third nerves. Another case is reported where a shell fragment entered the left orbit above the globe, which was destroyed. Ptosis appeared on the right side, with mydriasis and paralysis of the third nerve. The media were found to be clear and the papilla without change yet the eye was quite blind. A metallic foreign body was located near the sella turcica with probable retrobulbar damage not far from the chiasma.

Klauber (*Klin. Monatsbl. f. Augenheilk.*, Oct., 1917, Abstr. *Brit. Jour. Ophthal.*, June, 1919, p. 272) details a unique injury produced by a rifle-grenade. The soldier was unconscious for a few minutes, and on recovering found his left eye did not see well. He was unable to recognize objects in the upper part of the field. The wound of entry was in the middle of the forehead, close to the hair margin. He recovered completely, with the exception of some interference with taste and smell, and the eye condition described. The left pupil was rather smaller than the right, and this difference was increased by the use of cocain. Lachrymation on the left side was diminished, and the lids were less widely opened than on the right. The left optic disc was pale, most marked on the temporal side. V. was 6/36 in the left, and 6/6 in the right eye. The left field of vision showed complete loss of the upper temporal quadrant and a small adjacent sector of the upper nasal quadrant, including the fixation point. Careful testing with Bjerrum's screen showed that the whole temporal half of the right field to 6° (apparently normal on the ordinary perimeter) was less sensitive both for white and colors than the nasal half. Radiography showed a splinter about 7 mm. long, lying on the base of the skull, slightly to the left of the middle line, near the anterior end of the sella. Klauber points out that the conditions found indicated a complete tearing of the ventromedial and a slight injury of the ventrolateral part of the left nerve, together with some slight affection of the middle part of the right nerve.

The affection of the sympathetic tract he attributes to either injury of the carotid plexus or the hypothetical sympathetic centre of Karpus and Kreidl in the third ventricle.

In Birch-Hirschfeld's case, a soldier was injured by a rifle shot. He was unconscious for quite a time, and after recovery the right eye was found to be blind. Four months later, the reporter found a scar at the wound of entrance in the middle of the forehead, above the root of the nose. The point of exit was on the right side of the neck between the right inframaxillary angle and the insertion of the sterno-cleido-mastoid muscle. The right eye and its surroundings showed no external changes; it deviated a little outward; the pupil was enlarged and reacted slightly to light; motility was somewhat impaired; vision equalled fingers at 1 meter eccentrically. As the vitreous was only slightly opaque a good ophthalmoscopic view was obtained; the disc appeared to be separated into two parts vertically; both parts had a reddish color from each of which numerous arteries and veins emerged which could be traced far into the retina. The separating surface was covered by a grayish-white new formation projecting into the vitreous; there was an extensive chorio-retinitic focus with pigment and grayish-white patches; the retina was detached upon the temporal quadrant. Oblique laceration of the optic disc and a gaping wound of the sclera was diagnosed. An unusual feature of the case was the fact that the optic nerve did not become totally atrophic and that the central artery of the retina was not severed also.

In the lagophthalmus which sometimes results from extreme proptosis in the case of orbital foreign bodies, or in the lagophthalmus consequent upon facial paralysis suture of the lids is necessary when there are the first signs of corneal insensitiveness or drying.

Leriche (*Presse Médicale*, Apr. 17, 1919, No. 22, p. 205) suggests muscle transplantation as a remedy for this paralytic lagophthalmus where this is not made impossible owing to too great destruction of tissue. Where this is impossible, however, he has used section of the cervical sympathetic, a much neglected and valuable procedure, which is followed by retraction of the eyeball and narrowing of the palpebral fissure. In a case of the sort done four years prior to his report the result has been exceptionally good in that the patient closes his eyes as if by volition control while the previously intense lachrymation has subsided.

Gillies has suggested that this condition may be overcome by the implantation of cartilage into the upper and lower lids in a form comparable to a "wish-bone" but prepared in such a way that it would exert a constant elastic action tending toward closure of the wide-spread palpebral fissure.

Orbital cellulitis appearing in connection with a foreign body retained in the retrobulbar region is relatively rare and does not follow the course of the usual clinical orbital phlegmons which, in large measure, have their positions predetermined by the relation of the nasal sinus from which the inflammation has sprung to the nearest weak point in the orbital fascia. In military cases the spread of infection is more likely to be along the track of the missile or to be generalized in the orbit and the best form of incision in these cases is that through the lower lid just above the floor of the orbit, blunt dissection rather than sharp being used for opening into the abscess cavity. At times no pus is encountered but in these cases it either appears later or the process is aborted or relieved by the free flow of blood and serous fluid from the swollen lids.

While the retention of shrapnel bullets or lead casing in the orbits is rare, the presence of fine lead dust from broken bullets is not uncommon and as serious lead-poisoning has been noted by Loeper and Verpy (*Progres Médical*, June 5, 1919, p. 81) in cases where small fragments of lead were retained in the tissues, it is well that this possibility be not overlooked where no explanation can be found for unusual symptoms. They noticed a number of men who had apparently quite recovered from their gunshot or shell wound presented anemia, albuminuria or intestinal or nervous disturbances for which no explanation could be found unless the projectile still left in the tissues could be incriminated. A positive reaction for lead was obtained in the urine from six of the sixteen men tested. The projectile was a scrap of lead in these cases. Intact bullets did not seem to induce lead poisoning, being jacketed with another metal. Some of the men with a 20 gm. shrapnel ball in their tissues eliminated daily for months 15 mg. lead in the urine. The absorption of lead from the projectile varies with the chemical reactions of the tissues in which it is embedded, and with the activity of the circulation in the region. Absorption proceeded most actively in suppurating foci and the lung tissue seemed to be most favorable for it. Lead was found in the urine as early as twenty-five days after the injury and it kept up in two cases for three weeks after the projectile had been extracted.

Among the 38 wounded men examined, albuminuria was found in 4; high arterial pressure in 2, and severe anemia in 2; neurasthenia was pronounced in 2, with abolished tendon reflexes in the legs in one of these. In another case there was rebellious painful spastic constipation. The subsidence of these symptoms after removal of the projectile testifies to lead-poisoning as a causal factor. Examination of the urine for lead will warn when the projectile is beginning to give trouble. For this they collect the urine for two or three days, decompose the organic matter with hydrochloric acid and potassium chlorate (Fresenius and Babo technic), and after treating with sulphuretted hydrogen obtain the typical reactions with the sulphate of lead in the residue.

The great majority of disturbances of the motor apparatus of the eyes depend on direct or indirect injuries of the muscles, or of their nerves, in the orbit, or at the base of the skull, by the wounding bullet or by splinters of bone. In many cases the cause of a permanent limitation of motion is a cicatricial adhesion of the eyeball to the wall of the socket after a wound of the adnexa. Occasionally an excess of movement in a certain direction may be produced by a laceration of the facial ligaments. Enophthalmos and movements of retraction of the globe are not uncommon in consequence of demolition of the margins and walls of the orbit. Operative efforts to do away with diplopia are to be considered only when the condition is one of true paresis, not due to mechanical impediments, such as cicatricial adhesions, and laceration of muscles.

A unique form of injury has been noted in connection with superficial wounds of the cranium and the use of helmets, where the squeezing of the tissue of the scalp between the under surface of the non-yielding helmet and the uplifted fragments of the cranium give the picture of hemorrhagic extravasation about the eyes and lids hitherto noted as arising from a fracture into the anterior cranial fossa. Gamlen and Smith (*Brit. Jour. Surg.*, July, 1917, p. 37, Fig. 10) picture such a case in which the forehead is deformed into the shape of a "tower skull" by an uplifted large scale of the frontal bone which squeezed the scalp against the rigid helmet and produced profuse purplish mottling of the scalp.

B. Injuries of the bony orbit and adjacent extraorbital structures. These injuries naturally group themselves into (1) injuries of the orbit and the nasal sinuses, and (2) injuries of the orbit and adjacent cerebral structures; a division which is by no means rigidly drawn, as one of the most fatal of all cranial injuries is that of combined orbital, nasal and cerebral laceration and destruction.

(1) Combined injuries of the orbit and nasal sinuses have been noted much more commonly since systematic investigation of the nose has been undertaken in wounds of the head. They are of every possible type and variety of tissue defect, varying from the clean through and through perforation to great gaping holes with infected walls in place of the nose and orbits. The course which these cases run is determined almost wholly by the presence or absence of infection and this basic condition is, in turn, determined by the presence or absence of previous obstruction to nasal drainage and ventilation. Where no such defects have existed wounds of the sinuses are, for the most part, followed by suprisingly little sepsis and operative treatment, aside from the removal of adhesions, is seldom necessary.

The value of free drainage and good ventilation in the nose is nowhere more clearly shown than in wounds which have become moderately infected and which have involved the sockets and lids. Here, if reparative work is attempted before a normal intranasal condition is reestablished a chronic suppurative process in the lids, orbit, lachrymal ducts and always in the nose, is almost inevitable. With the renewal of intranasal circulation, as a preliminary measure however, healing occurs with unusual celerity. O'Malley was obliged to operate upon only 11 out of 50 cases of antral penetration and perforation on the ground of sepsis. In 11 others he operated for the removal of foreign bodies. He had 18 cases of eye involvement; in 10 the eye was lost, in 8 there were injuries to it of varying degree. Where the injury to the eye was not direct, it seemed to have been caused by the missile striking the malar bone, the shock of impact being communicated to the bony wall of the orbit. In some cases where epiphora resulted, this did not give much trouble in the ordinary way, but when playing games in a high wind, or motoring, the overflow of the tears was a nuisance. He thought the cause was hypertrophy of the inferior turbinate due to exposure to the winds, and as a result of its engorgement pressure was exerted on the tear duct. Removal of a portion of the soft tissue of the inferior turbinate seemed to cure this climatic cause of overflow.

Ormond notes that pain arising in consequence of inflammation of the sinuses after such injuries was sometimes referred by the patient to his eye. In two such cases blind eyes were removed on account of severe pain supposed to have originated in them but whose origin was proven later to have been in the nose.

With the osteomyelitis which occasionally follows perforation of the facial bones, especially by bullets, and which occurs secondarily to sinus infection, the osseous infection may involve any portion of the orbital wall and thereby induce orbital inflammations and their consequences. Radiographic examinations of these nasal cases are replete with surprises and not seldom when obvious wounds of entrance and of exit seem to have made the absence of foreign bodies certain, the radiogram shows that several missiles have entered the face at the same time and are imbedded in the bones or are free in the cavities, or that the parent missile has split into a number of smaller fragments upon contact with the bone.

Cords (Abstr. *Arch. Ophthal.,* Jan., 1918, p. 90) emphasizes the special importance of wounds of the frontal sinus, the posterior wall of which is often crushed. At the first operative intervention these cavities should be opened freely and good drainage given, or should be extirpated radically. Fissures in the posterior wall of the frontal sinus are particularly dangerous and when found, Cords lays bare a larger extent of dura. He also notes that tangent shots of the temporal region are not rare and that they are easily overlooked as wounds of the brain are likely to be hidden beneath the temporal muscle. Verticle or horizontal tangent wounds of the frontal region require free exposure by a curved incision through the brow or nose, evacuation of the crushed frontal sinus, very careful attention to the wound in the brain and open treatment. In fact the single basic object of treatment in wounds which involve any of the air cavities is to establish free drainage by open treatment. Frequent hot fomentations are often of aid in the septic open wounds of the naso-orbital region.

The prognosis of brain wounds produced through the orbit and nose is bad. Contusion of the brain, as an accompaniment of wounds which are purely orbital and nasal may result in death almost immediately but the usual cause of death is encephalitis, less often meningitis and as a late consequence brain abscess may end in sudden death, not infrequently after the passing of many months. Wounds of the large vessels are rarely the cause of death, although when the carotid artery or jugular vein are torn at the entrance to the skull, death comes immediately from hemorrhage or air embolism. Cords noted one death from hemorrhage of the internal maxillary artery.

A number of cases of unilateral and bilateral pulsating exophthalmus have been reported as a consequence of deep injuries of the orbit and of the cranial fossæ, several of which are reported in abstract: Guisez and Oudot (*Presse Médicale,* March 23, 1916, p. 129) describe an arteriovenous aneurysm of the internal carotid and cavernous sinus which developed after fracture of the ethmoid and sphenoid by a fragment of shell which lodged in the vicinity of the sella turcica. This gave rise to characteristic ocular symptoms, which subsided after ligature of the external and internal carotids on the affected side, combined with long-continued pressure by tampons of the maxillary sinus.

Angstein (*Klin. Monatsb. f. Augenheilk.,* 1916, p. 484) described a case of bilateral pulsating exophthalmos, caused by a wound in which the muscles of mastication and the sternomastoid of the left side were completely torn to pieces, the ramus of the lower jaw, the malar bone and the joint destroyed, and the facial nerve paralyzed. Later pulsation of the carotid could be felt, the veins of the upper eyelids were distended and tortuous; and both eyes protruded, the right 23 mm., the left 20 mm. The exophthalmos remained the same upon changing the patient's position. The intraocular tension was raised. A pulsation, synchronous with the beat of the heart, was felt by the hand placed on the closed lids. Over the entire skull a vesicular murmur could be heard, synchronous with the carotid pulse. After ligation of the carotid artery the exophthalmos and pulsation subsided. Subsequently fine pigment anomalies appeared in the retina, together with whitish lines of opacity and punctate hemorrhages in the left, although the vision remained normal in both eyes.

Mayou (*Trans. Ophthal. Soc. U. Kingdom,* Vol. xxxvii, p. 186) details the case of a soldier who was wounded by shrapnel entering behind the right mastoid process, and becoming lodged behind the left coronoid process of the temporal bone. When he presented himself he had a right facial paralysis with proptosis of the right eye, and pulsation could be felt by pressing the globe into the orbit. Ocular movements were limited and the ciliary vessels were dilated. A bruit could be heard over the orbit and head. Both eyes had corneal nebulæ. The case was one of arteriovenous aneurism, and was not improved by ligation of the internal carotid.

Cailland (*Arch. d'Ophtal.*, Nov.-Dec., 1917; Abstr. *Brit. Jour. Ophthal.*, June, 1919) publishes a case of bilateral pulsating exophthalmus caused by a shell fragment which penetrated the left malar region, traversed the maxillary sinus of the same side and lodged in the retro-pharyngeal space. Consciousness was lost for some hours, and on recovery the man found he could see with the right but not with the left eye. Fourteen days later an unsuccessful attempt was made to remove the shell fragment. About January 4 or 5, on looking in a mirror, the patient noticed some prominence of the left eye, and a few days later of the right eye. On February 4 he came under the care of Cailland. He then exhibited all the characteristics of double pulsating exophthalmos. On the right side there were proptosis, which could be easily reduced by pressure, chemosis, limitation of ocular movements, partial anesthesia of cornea. Pulsation was very noticeable to the finger, and a bruit was audible. The fundus oculi showed small arteries and slightly enlarged veins. Vision with — 7 D. was 0.3.

On the left side there was much edema of the lower lid. The exophthalmos and chemosis were more marked than on the right side, and ocular movements were more restricted. The globe could not be pressed back into the orbit, pulsation and bruit were very marked; the cornea was anesthetic and ulcerated in its lower half.

The subjective symptoms were comparatively slight: the man noticed a humming noise in his left ear, which had previously lost its hearing. He was not aware of any pulsating bruit. In spite of various methods of treatment, the local signs all increased, and the man's general condition deteriorated. By the end of March, 3½ months after the wound, the vision of the right eye was only 0.1. On this side compression of the carotid artery led to a reduction of the exophthalmos; on the left side no such result could be obtained. Cailland then asked a colleague to ligature the right common carotid. On April 6 this surgeon ligated the right internal carotid. Soon after the operation the exophthalmos on the right side became less, the chemosis almost disappeared. Pulsation persisted, but was less obvious, and a very faint bruit was audible. Complete blindness of the right eye ensued. On the left side no modification in the ocular or orbit conditions was obtained. Two days later all the symptoms on the right side reappeared in all their former severity. On April 13 the left internal carotid was tied. Before knotting the ligature the artery was compressed, and as this had no effect upon respiration, or cardiac action, the ligature was tied. On recovery of consciousness, the patient was comfortable and expressed himself as much relieved. There was an entire absence of pulsation or bruit, and the exophthalmos was greatly reduced.

Sixteen hours later right hemiplegia and aphasia supervened without loss of consciousness, but two days later a second cerebral attack was followed by loss of consciousness and death in fourteen hours. A post-mortem survey of the region of the cavernous sinus only, threw no light on the lesions caused by the original wound or the effect of the ligation of the arteries.

Other cases are reported by Salus (*Klin. Monatsb. f. Augenheilk.*, Vol. 60, p. 253), Cords (*loc. cit.*), Sattler (*Deutsch. Med. Woch.*, Vol. 42, p. 1306), von Szily (*Atlas*), and others.

Golovin (*Vestnik Ophtal.*, Nos. 2, 3, 4 and 5, 1917) reports four cases of traumatic pulsating exophthalmus occurring from civil injuries and a fifth resulting from a military injury, the man being struck in the open mouth by a rifle bullet which fractured the right lower jaw and lodged under the maxillary angle from which it was extracted. The man was unconscious for about a half hour and on waking became aware of a loud noise in his head and right ear. He observed immediately that the right eye was swollen and weeping; he was unable to open the lids and the eye appeared to be proptosed. Golovin explained the presence of the pulsating exophthalmus which was demonstrated as the result of the transmission of the blow through the tissues to the column of blood in the carotid with rupture within the cavernous sinus. Golovin advocates ligation of the superior ophthalmic vein for pulsating exophthalmus and the application of his method to this case, a double operation of ligature of the carotid and the superior ophthalmic vein, gave so satisfactory a result that the vision, which was almost lost before the operation, recovered to a considerable extent. Golovin believes that ligation of the superior ophthalmic vein is under all circumstances less dangerous than ligature of the common carotid. It is indicated particularly where the aneurism has involved dilation of the veins of the face. Where the cerebral symptoms (noise in the head and paralysis), are prominent, ligature of both the ophthalmic vein and the common carotid are indicated.

In all cases where, along with the symptoms of aneurism, there may be the smallest suspicion of a neoplasm of the orbit, resection of the outer wall of the orbit is called for to begin with, in order to provide free access. If there should be a tumor, its removal can be proceeded with. If the condition turns out to be a purely vascular distention, the access is sufficiently free, even if the dilated vessels should lie to the inner side of the orbit. In cases where the symptoms of aneurism leave no doubt as to the diagnosis, he considers the resection of the outer wall of the orbit unnecessary; as through a moderately sized incision made below the eyebrow, sufficient access can be obtained to effect the ligature of the vein without difficulty.

In cases of recurrence after, or failure from ligature of the common carotid, ligature of the vein is necessarily indicated as preferable to ligature of the carotid of the other side.

Among the unusual orbital accidents are *traumatic emphysema of the orbit* described by Beauvieux (*Arch. d'Ophtal.*, Vol. 36, pp. 366-8); *traumatic enophthalmus* which is fully described and freely illustrated by Pichler (Graefe's *Archiv. f. Ophthal.*, Vol. 95, p. 145), in a case of its extreme degree, the dislocation of the globe into the antrum of Highmore, by Kraupa-Runk (*Klin. Monatsb. f. Augenheilk.*, Vol. 56, p. 495). Rössler (*Wien. kl. Woch.*, p. 979, 1918) writes interestingly upon the changes in the cornea which follow wounds of the trigeminus.

Lesions of the lachrymal passages are relatively common as a result of wounds of the lids, the orbits and of the nose and its sinuses. Purulent dacryocystitis of the purely clinical type is also not rare, and displacements of the lower punctum from ectropion produced by cicatrices of superior maxillary lesions often cause troublesome epiphora. Not seldom traumatic anophthalmus and the various forms of badly ruptured globes are complicated by injury to the tear duct and its infection, and in these cases an irritating chronic suppuration of the socket may be set up and persist until the tear sac is extirpated. Lauber and Henning, in fact, after destruction of the eye remove the lachrymal gland, the conjunctival glands and the accessory glands in order to prevent secretions. Clean wounds of the lachrymal duct may be sutured according to the method proposed by Elschnig (*Klin. Mon. f. Aug.*, 55, p. 144) and used by him with successful functional results.

Von Szily investigated the normal and pathologic conditions of the lachrymal passages by means of roentgenographs. Two principal types constantly recur. In the first group the changes start from the so-called isthmus ductus lacrimalis. Beneath the sac with a comparatively broad duct a contraction takes place which later becomes complete. In another large portion of cases there is a gradually progressive disease and contraction of the duct from below. In both cases large ectasias and diverticuli of the sac may appear as time goes on, of which the roentgenograph first gives us a correct conception. He showed also pictures of tuberculosis of the lachrymal passages, of valvular occlusion in which abundant residual contents always remain after the tensely filled sac has been emptied by pressure, of acromegaly, of congenital atresia of the nasal opening, and of battle wounds of the lachrymal passages.

Morax and Désauges, among 1,510 wounded soldiers, under their care from September, 1914, till 1917, observed 22 instances of traumatic lesions of the lachrymal passages—13 from rifle bullets and 9 from shells and torpedoes. The lesion may be caused by direct injury of the lachrymal passages with or without fracture of the lachrymal bone or superior maxilla or indirectly from secondary involvement due to fracture of the latter bone.

It is exceptional for the lachrymal lesion to occur alone; the presence of other disturbances or lesions almost invariably brings it about that involvement of the lachrymal passages is unrecognized or neglected at first. The latter shows itself only by slight watering. Subsequent infection calls attention to the injury. The frequency of infection is very great—19 out of 22. It consists of a dacryocystitis with or without abscess. The time of the occurrence of this complication is very inconstant—in these cases in from 1 to 18 months after the wound. Such tardy complications are comparable to what is sometimes observed in fractures of the bones of the face or of the base of the cranium when the sinuses are involved.

Treatment of these traumatic lesions and their complications is beset with great difficulty; it is almost always impossible to reestablish permeability of the canal; extirpation of the sac is the only measure to arrest suppuration. In spite of the best applied treatment relapses are frequent; this is particularly the case when the mucous membrane of the sac has been lacerated, and when there is no longer a single cavity, but a number of diverticuli. It is only by minute dissection of the canaliculi, of the different portions of the mucous lining of the sac and duct, as far as the stricture, that it is possible to succeed in arresting the source of these very disturbing suppurations, even where the globe has been enucleated.

Reconstructive surgery of the eye, the socket and the orbit.

The remarkable functional and cosmetic results attained in cases, heretofore considered as hopeless, by the surgeons who restricted their endeavors to orbital and ocular, and to maxillo-facial reconstruction after military injuries, attests both to the spectacular progress made in plastic surgery during the war, and to the fact that war is not altogether an unmixed tragedy in its end results. Judging from the progress in oculo-facial plastic surgery made during the decade preceding the war, it would have required at least a half century to have reached the present pinnacle of plastic attainment. It is almost self-evident that quantity-production, whether it be of wounds or of industrial output, is the certain way of achieving correct methods of handling and of true conservation of the materials involved.

Before this war but few surgeons were more than theoretically aware of the principles underlying plastic surgery of the face and eyes, but the widespread diffusion and applicability of this knowledge which has followed the return of these surgical specialists to their civilian posts will, in time, yield functional and cosmetic results of the greatest economic value, particularly along the lines of industrial injuries and of the severer motor accidents. One of the great lessons we have learned is that this form of surgery involves surgical team work and that facial surgery is no longer the exclusive province of the general surgeon, who is usually clumsy in matters of small but important detail, but requires, for complete success, the efficient cooperation of the ophthalmic surgeon, the rhinologic surgeon, the aural surgeon, the dental surgeon and the general surgeon. This lesson must not be forgotten in our civil practice.

The relatively greater exposure of the head, the innumerable secondary missiles incident to trench warfare, and the unprecedented use of high explosive shells and machine guns have been the cause of the greater frequency of injuries of the face, the lids, orbits and eyes than has occurred in previous wars. The eyeball is most often injured, next often the lids and least often the orbits, although complicated wounds of the eyes are constantly met with in association with partial or complete destruction of one or both lids and frequently with such ruin of the bones which form the orbit that the nose or the pneumatic sinuses are opened into a single cavity continuous with the breached orbit. These injuries appear in every conceivable variety and form and demand the highest operative skill and judgment.

Reconstructive surgery of the sockets, lids and orbits will be considered under the headings of

I. Ocular protheses.

II. Restoration of the socket and the lids.

III. Hopeless or inoperable sockets.

I. Ocular protheses have hitherto failed of full success from the cosmetic standpoint owing to defective motility, to the usual existence of an unsightly depression in the region of the upper lid and to the fact that the irregular union of the muscles about a central scar made their action deforming. Amputation of the anterior segment of the eye, optico-ciliary neurectomy, exenteration of the globe, implantation into the eviscerated globe of various artificial vitreous bodies such as spheres of glass or of rare metals, and implantation of similar spheres into the space of Tenon have all had their vogue in the attempt at cosmetic improvement, and have all proved unsatisfactory. The solid spheres implanted in the globe have been expelled or absorbed or have undergone irritating chemical changes with but rare exceptions, and evisceration, as shown by Dor (*loc. cit.*) is frequently followed by irritative symptoms in the remaining eye which force enucleation.

The value of the method of evisceration with the removal of the scleral window containing the insertion of the optic nerve and the division of the nerve through the opening thus made, as proposed by Dimity (*Amer. Jour. Ophthal.*, Sept., 1919) has yet to stand the test of time, and the adjunct implantation of gold spheres or of solid spheres is as likely to be followed by late irritative results owing to chemical change, or late extrusion, as by any other form of bed formation. It is likely, however, that fat implantation combined with the proposed method may prove of value, as the excision of the optic nerve and the ciliary nerves and vessels through the posterior window in the sclera would seem to minimize the chance of persistent irritative changes of sympathetic nerve origin.

Evisceration, at best, however, does not give ideal results, as the scleral envelope gradually shrinks and collapses. Accordingly in military practice the present operation of election, considering both the ultimate safety of the remaining eye as well as the cosmetic result to be attained, is the implantation into the space of Tenon, not into the eviscerated globe, of living tissue such as fat from the thigh; spheres or discs of costal cartilage; osteo-periosteal grafts from the tibia; bone spheres created from the head of femora of cattle and calcined by subjection to fire; the heads of metatarsal or of metacarpal bones, and balls of pith from the elder or the sunflower, as approved of by Kuhnt.

Although all of these materials heal in well and apparently remain permanently, the most easily obtained of all and the most adaptable is fat obtained from the thigh and preferably with some of the fascia lata in connection, this preventing most of the relatively slight shrinkage which follows this special implantation. Before inserting the fatty globe, which should be made full-sized, it is advisable to place catgut sutures in the opposing rectus tendons which are then united over the fat, together with the capsule of Tenon and the conjunctiva. At times it is necessary to place several irregular sutures here in order to retain the fat until adhesion, which occurs with remarkable rapidity, is established. The author has done both the enucleation and the excision and implantation of fat under local injections of 4 per cent. cocain and 1 per cent. novocain many times and prefers this method to that of general anesthesia because of the greater dryness of the socket produced by the adrenalin-anesthetic combination, an effect which greatly furthers the immediate adhesion of the implanted fat to the orbital tissue. The injection of 1-10,000 adrenalin behind the globe as a preliminary to enucleation under general anesthesia has been used to the same end with much success.

In those not rare cases where there may not be sufficient conjunctiva to cover the implant, the transplantation of a Thiersch graft—or of fascia lata over the united tendons and Tenon's capsule has proven successful. The edges of this graft should be pushed well under the conjunctiva in order to prevent displacement. Valois (*Les Borgnes de la Guerre,* Paris, 1918) suggests that a lozenge of sclera, removed from the posterior surface of the enucleated globe, be sutured into the open space between the point of union of tendons and conjunctiva, the conjunctiva and this transplanted sclera being united. This procedure, while offered as a means of increasing the extent of motility of artificial eyes, also finds an application in cases of conjunctival defect where a covering for the fatty or other implant is required. Sourdille (*Arch. d'Ophtal.,* vol. 35, p. 386) introduces a skin graft, 28 by 30 mm. in diameter, and including a thin layer of fat, into Tenon's capsule. This fat is fixed by the threads previously passed through the recti tendons. In injuries complicated by palpebro-conjunctival or orbital lesions, especially where the malar bone or outer wall of the orbit has been destroyed, he has used bony grafts taken from the surface of the external malcolus.

Relative to the use of buttons or spheres of living costal cartilage, introduced by Carlotti and Balleul in 1915, Aynard (*Lancet,* Oct. 27, 1917) who uses two hemispherical buttons of cartilage cut from the eighth costal cartilage by means of a special trephine, and who implants these pegged together or sutured together into the form of a sphere, remarks the speed with which this transferred cartilage establishes fresh vascular connections with the tissues in its new vicinity and becomes fixed to the capsule in a recent enucleation, or to the surrounding tissues in cases of longer standing. Gillies has further modified cartilage implantation by making a ball and socket prothesis of the cartilage.

In uncomplicated cases fat implantation in the manner described above, gives so excellent a bed for a shell eye and the resulting movements, aspect and projection of the prothesis are so like those of the normal eye that it seldom requires the devices which are commonly used to complete the visual deception, such as the use of a plus or minus lens to make the eye appear larger or smaller and of a prism to alter its apparent position. Sometimes where a slight irregularity of the stump has resulted, an eye which nearly fits may require a little building up with paraffin or wax until it fits accurately, when the amended eye may be sent to the makers for duplication. The use of paraffin moulded in this way should be greatly extended in civil practice as it offers a simple and cheap means of making great cosmetic improvement in most of the usually ill-fitting artificial eyes seen in civil practice.

Terrien (*Arch. d'Ophtal.,* May-June, 1917) describes prothesic stumps under the heads of (a) natural stumps, (b) anophthalmic stumps including implantations, both of which have been discussed above and (c) artificial stumps, by which is meant the adaptation of small moulds of the conjunctival cavity made of ebonite with an india-rubber envelope, or of paraffin, or of the soft rubber employed for making impressions of teeth. Valois and Rouveix (*Ann. d'Ocul.,* cliii, 12) call attention to the importance of getting the whole moulding of the orbital cavity in one step, not only of the surface of the orbit but also of the transition folds. Plaster of Paris, or rather alabaster, is used by means of a small funnel with a large opening for the admission of the liquid plaster. On the side opposite to this funnel is a convex part reproducing the inner surface of the eyelids. From this mould a counter-mould is obtained having the exact aspect of the empty orbit. This, however, cannot be used without change, for while it gives the projection of the eyeball, the portions which are of greatest value are those which preserve the greatest number of movements. In studying the surfaces of orbital cavities attentively it is noticed that only certain portions of it are moving, others are immovable, while still others are deformed by movements. There is no rule for determining which of the movements can be utilized in evolving an artificial stump. In fact, often enough a band which apparently should be removed proves to be the origin of certain needed movements while in other cases mobility must be sought in some diverticulum of the conjunctival cul-de-sac. The essentials are that the movements must be utilized, the deformities neutralized. As Valoix and Rouveix correctly state: "When the moulding of the orbital cavity has been done, the final mould can be exactly like it only in the one position in which the cavity has been moulded. The least movement of the fundus of the orbit will suffice to change their relations.

"The prothesis must therefore be made in such a manner that these relations are maintained during the smallest movements even. In this way we have by a normal evolution come to know the inconveniences of rigid moulds and to replace them by hollow ones, which are elastic in the parts resting on the ocular stump. These moulds will hug the conjunctival surface in all its changes produced by whatever movements are still preserved." The anterior portion of the prothetic eye they describe is made of hard rubber or vulcanite, on which the appearance of a normal eye is reproduced in enamel or by any other procedure of painting. This constitutes the interpalpebral portion of the ball; against this rigid surface the opposing force of the lids must act.

The posterior part as well as the lateral ones of the mould are made of soft and elastic rubber. The space between the anterior and posterior walls is empty or rather filled with air.

This apparatus is essentially elastic, pneumatic, and hugs, without undue pressure, the sinuosities of the orbital cavity, copying its deformities, but transmitting the movements.

Its suppleness helps to maintain an elastic contact between the eyelids and the fundus of the orbital cavity. It will not by its weight, small as it is, fall into the inferior cul-de-sac, nor leave the place assigned to it by the moulding.

The mould is made of an almost living material, elastic rubber, which transmits the least movements of the eyelids or of the fundus of the cavity; it is in continued action. This relation is the best warrant that it will remain in place; moreover, its lightness helps to assure its stability.

It is useless to discuss how valuable such conditions are to the projection of the artificial eye and to the utilization of the least movements of the remaining muscles, if there are still any at our disposal.

These moulds do not break easily, on account of the material used in their composition, an advantage of great importance for the wounded who will wear them, many of whom will resume the hard work of laborers. In one of Valois' patients, the eyelids, the bulbar and palpebral conjunctivas and the cornea, were burned by molten metal. The eye was eviscerated. The end result was total symblepharon. Subsequent operation was refused. A mould of the orbital region was taken and studied. A zone was located in which active movements were present and a zone of relative fixation was noticed. A double prothesis was constructed, the one covering the fixed area or defect of the orbit and lids; and the second a glass prothesis attached to the first. The double prothesis was held in place by a spectacle frame, while the glass eye received its motility by the movements of the scleral stump through the eyelids.

Cosse (*Ann. d'Ocul.*, cliii, 7) has used dental "crown composition" as a prothesis. This is softened by immersion in hot water, is easily moulded, well borne by the conjunctiva and keeps its shape when cool. The softened mass is introduced into the conjunctival sac in such an amount as to fill the entire space between the lids and stump. The surplus is cut away, the mould is removed and is then hardened by immersion in water. On the anterior surface a pupil, iris and conjunctival vessels are painted. Where cicatricial bands occur the mould is enlarged at the corresponding point of obliteration, which gradually yields under the continuous gentle pressure and which so often restores or deepens a groove, that the mould is not only better borne, but sacs have even been restored which otherwise would have required extensive plastic operations. Coulson advocates a similar treatment where cicatricial bands and bony lesions have changed the orbital cavity, while Terrien (*loc. cit.*) states that if the cul-de-sacs are contracted, or irregular and will not hold an artificial eye, progressive dilatation by globes or olives of increasing size is a simple and effective procedure. It is generally preferable to, and more successful than, any operative measures designed to restore a contracted conjunctival cavity.

Lauber and Henning, after destruction of the eye, remove the lachrymal gland, the conjunctival glands and the accessories in order to prevent secretions. Necessary plastic operations upon the orbital border are made to insure the retention of the prothesis. A plaster cast is given to the patient, which furnishes him the model for the prothesis, made of a plaster mass.

I. Restoration of the socket. The more common defects noted in the socket are cicatricial bands, cicatricial contractions and partial or complete symblepharon.

According to Valois (*loc. cit.*) the *conjunctival bands* usually start from the surface wound, and most often from lid wounds. A dense fibrous tract unites the two opposing walls, all elasticity of the region is lost and no movement is permitted. Sometimes this is connected with the deeper parts of the orbit. In other cases a band forms a bridge which crosses the cul-de-sac. Valois believes that the only practical treatment for these bands is to make an incision of about 3 or 4 cm. along the outer margin of the orbit detaching the one eyelid from the other. A suture is passed through each lid which is retracted thereby. The conjunctiva is dissected free from the underlying cicatricial tissue by scissors and the various cicatricial bands are thoroughly excised. The margins of the lids are freshened and sutured, after an olivary body has been inserted, and the lids remain united over the olive for about 3 to 4 months.

Ordinarily, where irregularity and contraction make the insertion of a prothesis difficult the development of a suitable cavity is aided by the insertion of a provisional body which consists of polished ebony made in the form of a half olive and slightly curved. A cross on the anterior surface indicates the correct axis. This splint is of greatest value when applied directly after enucleation; it prevents deformities and post-operative adhesions and indicates the form and size of the socket. With the persistence of a fistula after enucleation it is of value to use a fenestrated olive for the purpose of better drainage until the cause of the fistula—necrotic bone or missile—is removed. In order that the pressure shall be exerted in a posterior direction a compression-bandage is applied during the entire time of use of the bougie. The rapidity with which the space between the lids and orbital scar tissue is enlarged is surprising. Valois and Rouveix have also succeeded in deepening the conjunctival sac and even in forming a new one by the introduction of a dilator shaped like an eye-speculum, which, by its spring effect, exerts a continuous mild pressure upwards and downwards. They frequently use both this form of dilator and the olivary bougies. Where cicatricial bands prevent the introduction of any form of dilator, such bands are carefully dissected out and are replaced by a Thiersch graft over which a dilator is immediately applied in order to retain the graft in place.

Coulomb has obtained good results in small cavities by gradual dilatation with olive-shaped splints of increasing size, the wearing of which further exerts a good effect upon the shape of the cavity.

The contraction of conjunctival scars which follow injuries to the orbit creates situations which are often difficult to overcome. In general *the principle of treating contracted sockets and cul-de-sacs is that the cavity must be enlarged by the addition of new tissue.* Such tissue is obtained by the use of (a) pedunculated flaps from the adjoining or a remote region, utilized by twisting their pedicles and bridging the outer canthus, and by the use of (b) autogenous grafts of buccal or conjunctival mucous membrane, of the modified preputial skin, or by the transplantation of various forms of skin, varying in thickness from that of the entire skin to merely a superficial layer. In this connection it must be remembered that the *underlying principle of grafting is that all tissue grafts which are not autogenous will inevitably be absorbed or will be replaced by fibrous tissue.*

One of the simplest and yet most distressing of the forms of conjunctival scars which lead to manifold degrees of contraction of the conjunctival cul-de-sacs and of the socket is symblepharon. This may occur merely in the form of adhesions between an eye with good vision and the lids, between the lids and an injured globe which has fairly well preserved form, or between the lids and the remnants of the orbital contents and these adhesions exist in every possible form of incomplete and complete symblepharon. Such adhesions, even if of limited extent are difficult to overcome and the measures needful to that end vary with the extent and position of adhesion and of involvement at the upper or lower lid. Kuhnt (*loc. cit.*) draws upon his large experience to advise the division of the adhesions, in cases of symblepharon of the lower lid, the separation of the tissues up beyond the old fornix and the excision of all the larger masses or strands of scar tissue. The wound surface of the sclera should then be covered with conjunctiva from the same eye (lateral displacement or Teale's flaps) or from the other eye, or in case of necessity with mucous membrane from the lip. The covering of the inner surface of the eyelid should be accomplished with mucous membrane from the mouth or with skin. The skin may be taken in the form of a pedunculated flap from the upper cheek (Rogmann) twisted inward through a buttonhole, or as a non-pedunculated flap or graft.

It is important for the success of operations for symblepharon by flap and simple tissue transplantation (1) To be able to operate conveniently and see clearly by performing a preliminary external blepharotomy, extending the incision through the skin .5 to 1 cm. beyond the bony ridge and usually adding a second incision at the temporal end extending 1 to 1.5 cm. perpendicularly up or down. (2) It is important to suture the conjunctiva, whether laterally displaced in pedunculated or non-pedunculated flaps, firmly to the sclera, the anterior part of the tendon of the inferior rectus or to Tenon's capsule; (3) The mucous membrane or skin for the eyelid should be transplanted not in a state of tension, but in maximal involution and amply large.

The whole surface of the scleral wound need not be covered with conjunctiva or mucous membrane, it is sufficient to cover the area contiguous to the new fornix. The surface near the cornea will epithelialize comparatively rapidly.

If there is a wing-shaped extension of the conjunctiva upon the cornea it may be used to cover the inner surface of the eyelid.

If the conjunctiva is so reduced in volume that lateral displacement is impossible and if conjunctiva cannot be taken from the other eye, then mucous membrane from the lip or in case of necessity even a skin graft should be used to cover the wound surface of the eyeball and the part near the fornix. The durability of the fornix is dependent on the firm suturing of the non-pedunculated flaps. A Gullstrand plate clothed in a large non-pedunculated flap of skin can be employed successfully to cover the surface of both wounds when inserted and attached to the eyelid. Symblephara of the upper eyelid are difficult to combat and call for transplantation of mucous membrane of the mouth upon the wound surface. The upper border of the mucous membrane is attached to the fan-shaped fascia of the superior rectus muscle (H. Wolff). The lower to the border of the lid with mattress suture. For the covering of the bulbar wound one should employ lateral displacement of bridged flaps from the conjunctiva of the same eye in the first place, secondly, transplantation of conjunctiva from the other eye, and finally mucous membrane from the lip or a skin graft. In all cases careful suturing to the substratum in the new fornix is necessary.

Of the many flap and simple graft methods described Kuhnt has found only three satisfactory in the treatment of the common symblephara of the lower lid:

1. Temporary detachment of the eyelid according to Czermak; blepharotomia externa, incision along the lower orbital ridge to 1.5 cm. below the inner cornea; covering of the wound surfaces of orbit and lid with Thiersch grafts; interposition of a strip of gutta percha paper; dressing as soon as the grafts have healed, the edge of the eyelids are again freshened and the lid brought back and secured in its normal position.

2. The wound surface of the eyelid is turned outward with strong sutures covered with skin grafts and replaced when the grafts are definitely healed.

3. Introduction of protheses suitable in size and form. These are covered with skin grafts and carefully introduced between eyelid and orbital tissue (May). This method is without doubt the most convenient and simple and is sufficient for most cases. Unfortunately the fornix, although made deep by carefully severing all scar tissue and penetrating deep into the loose tissue of the orbit, usually shrinks gradually and sometimes becomes completely obliterated. One should not speak of real success until at least half a year has passed.

The following rules, gained by experience, are of general importance in obtaining good and lasting results.

1. One should not operate too soon, not until maximum scar contraction has taken place. It is important that the processes of otitis and periostitis, which always contract the orbit considerably should have come to a complete standstill or at least, be well advanced in the stage of retrogression.

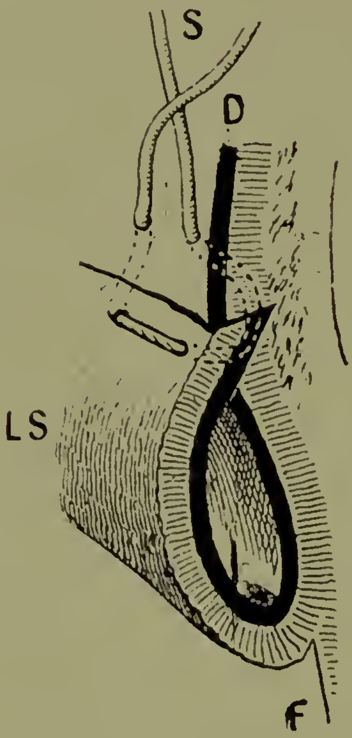
2. Scar tissue should be severed deep into the orbital tissue or even, where possible, removed.

3. The skin flaps or grafts should be transplanted in a state of maximum contraction.

4. Empyema or pus should not be present anywhere in the nose, the sinuses or on the head.

For the care of symblepharon of the upper lid with anophthalmus the same methods of procedure hold good in general, although of course Czermak's method cannot be used.

Morax (*Ann. d'Ocul.,* Vol. 154, p. 321, Abstr. *Amer. Jour. Ophthal.,* Oct., 1918, p. 171) observes that whereas partial symblepharon can generally be managed readily, such is not the case in total symblepharon with complete abolition of the conjunctival sac. The formation of a new cavity for prothesis is a most difficult problem. The tendency to retraction and contraction of the orbital tissues is such that the most extensive and perfect graft suffers such retraction, that the new cavity decreases greatly and may even disappear almost entirely. To obviate this tendency, Morax has devised a procedure which consists essentially in the formation of two wide "trap doors," the raw surfaces of which are turned outwards above and below by suturing their edges to the skin after freshening the latter. Wide epidermal grafts from the arm, thigh, or abdominal wall are then applied to the raw surfaces.

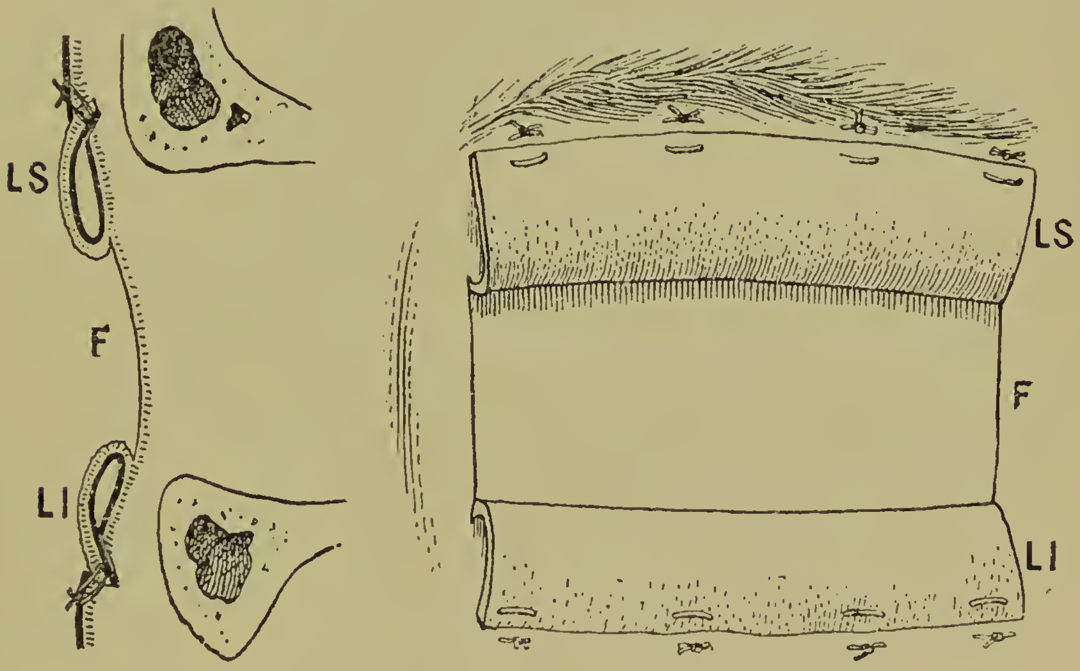


Morax Method of Placing Sutures to Secure Firm Union of Edge of Flap. S suture; D epidermis; L S skin flap; F raw surface left at bottom of socket.

At the end of three weeks the "trap doors" are replaced and sutured together at their free margins after freshening. A shell of lead or enamel is placed and allowed to remain between the doors, the bottom of the cavity being now covered with the graft. At the expiration of from six weeks to three months, the palpebral margins are cut and prothesis is possible. The same procedure is applicable where the orbital cavity is still occupied by a globe or stump.

Repair is difficult also in those cases of perforating injuries of the eyelids, nose or sinuses in which the inner angle of the eye has been drawn downward and inward and is firmly adherent. Kuhnt obtained good results by making an incision on the crista lacrimalis anterior, beginning 1 cm. above the ligament and extending downward to the incisura infraorbitalis or even further temporally to the rim of the orbit. The periorbita was then loosened with an elevator about 3 cm. deep and the whole mobilized contents of the orbit with the eyelid were sufficiently raised. Firm sutures both to the periosteum and to and in the eyelid assure union in the correct position.

A sufficiently large pedunculated flap must be drawn over if the skin in the region of the lachrymal sac and inner cornea of the eye has been destroyed by the injury.



Morax Operation for Total Symblepharon. Skin flap dissected up, and free from edge attached to skin at upper and lower margins of socket. Left in vertical section. Right as viewed from the front. L S upper flap. L I lower flap, F raw surface.

In those rare cases in which the nasal portion of both upper and lower eyelid have been lost there is usually also destruction of the eye. In these cases blepharoplasty is performed first on one eye and then on the other. If the eyeball is still functioning as organ of sight or at least retains its form, Landolt's procedure seems justified. However, it will usually be necessary, in order to relax the eyelid diaphragm sufficiently, to sever the skin muscle layer and the fascia, with subsequent transplantation of grafts.

Numerous forms of sliding and pedicled flaps have been employed for reconstructing the lower fornix, mainly the methods of Snellen, Maxwell, Dieffenbach, Harlan, Rogman or some modification of these procedures.

Danis (*Ann. d'Ocul.*, Febr., 1916 and *Brit. Jour. Ophthal.*, June, 1918, p. 332-5) reconstructs the lower cul-de-sac by cutaneous autoplasty, modifying Snellen's method, and turning a pedunculated flap of skin from the temporal region over to the lower fornix where its margins are united to those of the lacerated palpebral conjunctiva.

Maxwell's operation for the restoration of the lower cul-de-sac is also available in many of these military injuries, although the lid tends to ectropionize later at its outer portion, a fault which can be avoided by making a narrower flap than was proposed by Maxwell. The little pucker of the skin which forms below the lid, if not spontaneously taken up, is easily excised. This operation, as detailed by Schwenck and Posey (*Ann. Ophthal.*, Nov., 1918, p. 576), embraces an incision along the whole length of the bottom of the shallow cul-de-sac, some 5 or 6 mm. deep throughout its extent. An incision is now made in the skin of the lid about ½ cm. below the margin of the lid and a second incision is curved below this, thus enclosing a semilunar area of skin about 12 mm. broad in its widest part, which is to line the new cul-de-sac. The upper limiting incision of this skin-crescent is now deepened until it joins the incision in the cul-de-sac, the margin of the lower lid now forming a bridge attached only by its extremities. The crescent is dissected from its borders until only about 1/6 of the whole, near the center, remains attached to the subjacent tissues.

The bridge of skin bearing the lashes is now held forward and the crescent slipped under, its extremities being sutured into the angles of the first incision and its upper border being held in place by two or three sutures. The lower border is next brought up and stitched to the conjunctival edge of the bridge, thus doubling the crescent upon itself and forming a groove, the posterior wall of which is made of the upper, the anterior and the lower half of the crescent, the undissected pedicle holding the floor of the groove down. The closure of the wound on the lid surface has to be done with much care as the edges are of unequal length. The sutures are, therefore, placed first in the center of both edges and then midway on each side, continuing this method of suture until coaptation is complete. A conformer with a central opening for irrigation and drainage is introduced for 7 to 10 days in order to depress the cul-de-sac during healing.

Schwenck and Posey (*loc. cit.*) have applied Maxwell's ingenious method of transposition of skin for the restoration of the lower cul-de-sac by taking skin from some point above the orbit in order to reform the upper cul-de-sac. Work in this region is complicated by the presence of the levator. Healing, however, is very rapid here and the flaps show easy adaptability and marked vitality. An exact planning of the incision and precise marginal coaptation insure prompt healing and no especial scarring. The method offered by these operators consists of a careful separation of the margins of the two lids and free dissection of the underlying tissues. The external canthus is divided. The lower cul-de-sac is restored by Maxwell's method and the upper by transposing long flaps taken from the forehead above the brow, care being taken to include no hairs in the margin of the flap. The edges of the flap must be nicely coaptated to the margin of the upper lid and the upper border of the skin secured by the Maxwell procedure. The restoration of the external canthus is now essential to the retention of the conformer and must be firmly made by passing two double-needled sutures of No. 4 silk through the skin of the upper pillar of the old canthus and out through the raw surface of the lower pillar, on the skin surface of which they are tied over buttons. The pedicle of the flap is thus buried under this bridge of tissue, and unless the tension on the pillars is too great, union is prompt and satisfactory. Should the tissues give way, however, the canthus may be restored later by excising a diamond-shaped area of skin from the pedicle of the flap and uniting the edges of the denuded area in the manner described. No sinus or fistulous tract results from thus burying the skin beneath the united pillars nor does discomfort arise from hairy outgrowth from the flap. During the first month there is considerable desquamation of the skin but this lessens and the socket dries and becomes increasingly commodious under the influence of the conformer which is in the shape of an artificial eye and which gradually moulds the orbit into the shape necessary for the retention of a prothesis. A firm bandage is applied over the orbit with its prothesis for at least two weeks.

In Golovine's operation for supplying a socket suitable for an artificial eye, where there has been great loss of intraorbital tissue, a tongue of skin from the temple is slipped into the orbit beneath an undisturbed bridge of skin at the outer aspect of the orbit. Where the occlusion is incomplete and some conjunctiva is still present this may be freed and transferred to cover the lower lid, while the raw area thus created in the bulbar tissues is covered by a skin graft placed over a conformer, which is kept in place for about 8 days after which an artificial eye is soon introduced. Retaining conjunctival stitches which are placed through the entire thickness of the lid may be made to exaggerate the sulcus by tightening them daily after the fourth day although it is wisest not to carry this to the full point of cutting through the lid.

Restoration of the sulci by the Esser inlay method will be considered in detail under the heading of *Reconstruction of the Eyelids.*

The frequency of tissue defects in the lids as well as in the adjoining soft and bony tissues has led to a far better evaluation of the procedures offered for their correction than would have been possible in view of the relatively rare incidence of such injuries in civil and industrial traumas. Some of the old plastic operations have been discarded as inapplicable to military injuries, one epochal advance in plastic surgery has appeared, that of the epithelial inlay method of Esser and has been the means of overcoming many hitherto intractable deformities, while the relation between early treatment and subsequent deformity has been clearly established and formulated.

The importance of early treatment and of the form which this treatment takes cannot be overemphasized. As has been repeatedly stated débridement, which has proven of such great value elsewhere in the body, is inapplicable to injuries of the eyes and their adnexa, and as a consequence, although early reparative work is of the greatest value and may be immediately curative, primary union is less often obtained, and the operative scarring not infrequently further complicates that of the injury when the problem comes up for its final operative solution.

The plastic gains obtained by immediate reconstructive attempts so far outweigh the minor risks of failure, however, as to be in no wise deterrent in every case of traumatic lid defects, unless complicated by other injuries of such extreme general gravity as to make any cosmetic surgery impious. In general, *delayed treatment, and infection influence local recovery and restoration fully as much if not more than the original loss of tissue.* Infection is now recognized as the chief factor in delayed union, hence the rule, which has been very generally adopted, that wounds of the lids are to be cleaned thoroughly, only such tissue removed as is definitely devitalized, and sutures placed to restore the tissues to as near to normal position and appearance as possible, particularly in the canthal regions. In most of this early work drainage to some extent should be provided if possible, and especially if the wounded man faces transportation.

The actual reconstruction of the tissue and contractural defects which follow lid injuries is done, for the most part, weeks or months after their occurrence. In those graver cases where the loss of tissue, infection and scarring have been serious, plastic work is not considered until the wound has completely healed and maximum contracture obtained, these conditions being essential for the best results.

Three elementary points in the plastic surgery of the lids must be emphasized: (a) An individual plan must be adopted to fit the peculiar conditions of each case of lid defect; (b) it is a mistake to attempt too much in one sitting, especially where a serious deformity exists, and (c) plastic operations must not be planned to appear beautiful at the moment of their completion. There is always considerable contraction in the flaps and grafts and the reconstruction which leaves the table as an accurate replica of the region before its injury is likely to prove much more defective later as a result of this contraction, than the wound with its skin edges so elevated by excess of new tissue that they appear as protuberances.

Plastic surgery of the lids may be described according to the means of repair employed as reconstruction with (a) sliding and flaps, (b) pedunculated flaps from the adjacent tissues, (c) pedunculated flaps from a distance and (d) epithelial inlays and outlays (Esser's method and its modification).

Nearly all of these methods, save the great flap operations for covering gross tissue defects, are carried out under local anesthesia with or without an initial injection of morphia according to the nervous type of patient. Up to 12 cc. of 1 per cent. novocain can be injected if necessary without general effect. Tincture of iodine is the main reliance for local preparation and antitetanus serum should be a routine preliminary, combined in suspicious cases with antistreptococcic serum. Careful massage is of value, when the wounds have healed sufficiently firmly to permit, in producing smooth and well-vitalized tissue.

Conditions of the lids which require reconstruction after battle injury vary from the traumatic defects of small colobomata to more or less complete loss of one or both lids and include the most disfiguring types of inversions and eversions of the lids as a whole or in part, the result of scar tissue contractions.

The general considerations of military plastic surgery of the lids are given by Butler (*Ann. Ophthal.*, March, 1919, p. 103) and by Kuhnt, both of whom are freely drawn upon for the following detail:

The V Y plastic method for *repair of colobomata* have proven unsuitable save in the most trivial cases.

The first essential in all plastic work is to avoid tension and, when this is impossible, to reduce it to a minimum and to transfer the tension to a spot where aseptic healing is more certain than at the actual seat of the injury. The defect in the V Y principle is that it involves considerable tension at the site of the deformity and close to the lid edges. Suppuration is more likely to occur here and it may lead to a bad result with an unsightly cicatrix in an exposed position. Although apparently less severe than the flap method, in actual practice the V Y leaves more visible scars and generally fails to cure the malposition of the lid.

In the large majority of such injuries a pedunculated flap gives the best results, although when the deformity has been produced by burns, a flap cannot always be obtained and grafting may be required. With the pedunculated flap the degree of success is largely influenced by the state of the lid edges: if large portions of the lid have disappeared and much fibrous tissue must be cut away, the new lid must be built up by successive stages and the final result, though a veritable triumph of surgical skill when contrasted with the original defect, is apt to be defective, while with an uninjured lid margin, a carefully planned operation usually produces a satisfactory lid.

The Wolff, or whole-skin graft, is sometimes very successful but is uncertain and has been almost wholly superceded by the Esser epithelial inlay and its modifications.

Pedunculated flaps, generally cut from the cheek or temple, have given such uniformly good results that Butler uses them in preference to any other method when the conditions are favorable. Even apparently trivial displacements of the lids are more satisfactorily treated by flaps than by seemingly less formidable procedures, as in all but the slightest deformities a pedunculated flap remedies the defect with certainty and without the production of unsightly scars. Unlike the V Y method, if some suppuration occurs along the edge of the transplanted flap the final result is not prejudiced.

The technic of the flap method of rebuilding lid defects is simple: An incision is made below or above the edge of the displaced lid and all adhesions and bands are freely separated. They often run deeply into the orbit. The skin is undermined till the lid lies easily in its normal position. The length and width of the defect are now measured with compasses and a suitable flap marked out. It starts from the outer edge of the wound and extends upward for the same length as the wound.

The external incision is now carried as low down as the internal, the part left below being as long as the flap is wide. The flap is next dissected up first with scalpel and then with scissors till it rotates freely with no wrinkle at the turn. The base should be separated as little as possible to leave a good blood supply. The end of the flap must be left blunt and the depth of the dissection is just as much as comes naturally. Catgut sutures are used. The flap will be found to be healed firmly in place in about a week.

In cases where a depressed scar is caused by loss of bone, the cavity left when all the redundant fibrous tissue is cut away, can be filled with fat from the buttocks. Originally the fat was inserted when the flap was made, but the fat is liable to suppurate and the better plan is to insert it at a subsequent operation.

Suppuration in the fat does not imply that it fails in its object for it becomes changed into a fibrous mass which more or less fills the cavity. As a matter of fact a simple flap operation rarely, if ever, suppurates but practically always unites by first intention. When the deformity is situated at the inner aspect of the lids, flaps may be cut from the nose and forehead and the scars become almost invisible with surprising rapidity.

A modification of the flap operation permits the replacement of the eyebrow and the lashes. Butler details a case where the right brow was entirely burned off leaving a smooth surface of scar tissue, the lids being so badly retracted as to cause complete lagophthalmus. The upper lid was brought down by a pedunculated flap which healed without obvious scarring, while the lower lid was brought up by means of an Esser epithelial outlay. The thick and bushy left brow was shaved and accurately split along its whole extent and a flap cut ¼ in width comprising half the eyebrow, with its base, placed toward the nose, made broader. This flap was rotated across the nose and placed in the bed created for it above the left eye. The base of the flap was divided under local anesthesia about two weeks later.

The reconstruction of eyelashes is more difficult but they may be manufactured from the brow as in a case which had lost the inner half of the eyelid, including the edge. The defect was supplied by a flap from the temple including the outer tip of the eyebrow. When this flap was in position the skin which bore the hairs lay vertically, so a month later this brow-bearing strip was cut as a secondary flap with its base near the lid margin and was rotated to lie along the lid edge in such a way that the hairs pointed downwards. The illusion is complete in such cases especially where artificial eyes are worn and distichiasis is harmless. In any case with a suitable brow this method can be utilized.

Grout advises that if possible the wound of closure of colobomas of the lid should not enter the intermarginal line at right angles, but obliquely, thereby increasing the chances of a good result and minimizing the risk of notching of the margin in case of failure of the sutures to hold.

For coloboma of the inner canthus, where the lid has usually been torn away for the attachment and anchored below in an ectropionized position, the method of Blaskovics (*Arch. f. Augenheilk.*, Vol. lxxxi, 1916) is especially adapted. Here the scar is outlined by two parallel incisions which are joined at their extremities and so excise the scar tissue as well as its lateral strands that the lower lid lies perfectly free. A flap is now formed at the inner margin of the wound, with its base at the level of the angle of the lids.

A straight incision is next made into the skin at the temporal margin of the wound just below the adherent margin of the wound. This small incision gapes in the form of a triangle and serves to receive the little flap which has previously been formed. The wound edges are carefully united, the little spur-like flap fitting smoothly into the gaping triangle, and in the subsequent healing this particular point of union practically always proves strong enough to retain the lid in excellent position.

Blaskovics (*ibid*) presents another procedure suited for those uncommon colobomata of the lower lid in which the margin has suffered in its mid-portion with a cicatricial area and resulting ectropion. The first incision is made about 1 cm. below and parallel with the margin of the lid, throughout the whole length of the lid. The scar is then circumscribed by two incisions which run vertical to the margin of the lid and completely separate the bridging flap. The scar is thoroughly dissected, with its lateral expansions, and the margins of the coloboma are approximated by three interrupted sutures. The ectropion is thereby corrected and a semilunar raw surface is formed beneath the sutured lateral flap.

This crescentic defect is covered by making an incision which runs from a point 1.5 to 2 cm. from the inner horn of the crescent down and out on the cheek. A Burrows triangle is made at the end of the incision and the pointed flap with subcutaneous fat is then dissected as far as its base and sutured in its new position. While this operation was devised primarily for coloboma, according to Grout, it developed good results in cicatricial ectropion, where, after the first incision is made parallel to the lid margin, the skin between the incision and the lid margin is dissected up and scar tissue removed so that the lid is brought into position against the globe. The second incision begins at the inner end of the defect and runs down on to the cheek, ending in a Burrows triangle. The flap is then undermined as in the preceding operation and the defect covered by it.

Where a central coloboma of the upper lid is associated with a considerable loss of tissue a Wickeriewics plastic or the Landoldt operation are of value. In the former, the transfer of tissue from the lower lid to fill the gap in the upper leaves a decided disfigurement in the lower lid, making the Landoldt operation preferable, where possible. In this procedure, when the coloboma involves the inner third of the lid, its edges are trimmed and an intermarginal incision is made out to the external canthus, and from here a curved incision is extended upward for 1.5 to 2 cm. The intermarginal incision is then deepened until the lid is split into two parts, the quadrangular skin flap thus formed being slid over the defect in the lid and sutured into position. The secondary defect produced is covered later by a Thiersch graft.

Kuhnt's treatment of coloboma of the eyelid calls for procedures varying according to the breadth and position of the coloboma (nasal, medial, temporal), also according to the involvement of the tarsal part alone or the whole breadth of the eyelid, and according to whether the coloboma adheres with scar tissue to the bony edge of the orbit or not.

Direct union is usually possible in the generally triangular, medial tarsal colobomas if they are not broader than at most 1 cm. and their edges have been properly freshened. If the tension resulting is great, it may be relaxed with external blepharotomy with subsequent severing of all the tissue of the eyelid between skin and conjunctiva, especially after freeing it from the fibrous strands extending between the tips of the tarsus and the orbital wall. If necessary, one may also add a perpendicular incision about 1 mm. temporally from the punctura lacrimale through tarsus and conjunctiva. A rule valid in all coloboma cases should be especially emphasized, and that is that the edge of the lid should jut out convexly upward or downward, as the perpendicular suture of the two edges of the wound always forms a somewhat retracting scar and this will otherwise easily cause an indentation. In tarsal coloboma the edge should be placed about 1 to 1.5 mm. higher; in coloboma extending to the orbital margin 2 to 3 mm.; and in those adherent to the bone 4 to 5 mm.

Raising the edge is accomplished in the most simple manner by making the edges of the coloboma oval i. e., curving convexly, especially in the upper or lower part of the tarsus, and also by incising through the tarso-orbital fascia for some distance parallel to the bone.

The colobomas of the whole breadth of the eyelid usually call for thorough excision of the surrounding scar tissue, convex curving of the edges, incision through the fascia and besides these also a horizontal incision through the anterior surface of the lid on the margo orbitalis, in order to permit certain union by lateral displacement and suture. In wide colobomas even this frequently does not relax the tissues enough, displacement nasally of the whole temporal part of the lid becomes necessary: incision lengthening the incision of the blepharotomia externa 1.5 to 2 cm. beyond the rim of the orbita, addition of a second incision extending downward or upward and medially at an angle of 35 to 40°, mobilization of the skin flap as far as the orbital rim, and transcision of the fascia of the eyelid temporally and above, temporally or below.

Broad colobomas adherent to the bone and usually associated with marked ectropion are difficult of repair, especially when the orbital rim or the maxillary sinus is injured at the same time. They cannot, of course, be repaired until the sinusitis is cured or at least there is no longer any secretion.

Kuhnt, basing on extensive experience, recommends the following mode of procedure in the medial forms:

1. Vertical incision through the adherent scar tissue from the conjunctiva into the sound part of the cheek, extirpation of the always considerable masses of scar tissue and the severance of all larger strands extending laterally into the lid and posteriorly into the orbit. 2. Incision through the anterior surface of the eyelid and laterally through the fascia tarso-orbitalis parallel to the edge of the eyelid and 2.5 to 3 cm. from it. 3. Shortening of the edge of the lid which has become too long on account of the stretching. 4. Transplantation of solid fat with fascia lata from the lateral surface of the thigh in order to repair and fill out the hollow made in excising the scar tissue and raising the lid. 5. Firm suturing of the two lid flaps so that the edge of the lid at the point of suture will at first project convexly about 4 to 5 mm. more than what is desired later.

The cosmetic success, which after primary union is usually astoundingly good, in some cases diminishes gradually on account of the inevitable atrophy of the transplanted fat tissue. For this reason also prevention by means of raising the edge of the eyelid is necessary.

Kuhnt was unable to get satisfactory results with those methods employing only the lateral displacement of the parts of the lid, or with those in which one or both of these parts is split into anterior and posterior horizontally and drawn over the defect after it had first been mobilized by means of a perpendicular incision at the outer canthus of the eye and extending up to the eyebrow or to the orbital rim.

Kuhnt (*loc. cit.*) comparing ectropion of the upper and lower lids, states that in ectropion of the lower lid, even complete, the function of the eye need not have suffered but it invariably does in even moderate ectropion of the upper lid.

He divides the reconstructive blepharoplasty into 3 steps; the releasing of the eyelid, the extirpation of scar tissue with smoothing and leveling of the wound surface, and the covering of this surface by drawing over adjacent skin or transplanting other tissue.

In releasing the ectropionized lid the incision should never be placed at the edge of the eyelid, but rather as far from it as possible, on an average 0.5 to 1.0 cm. from it. The skin is then detached from the underlying scar tissue with flat section with broad curved scalpel, extending down to or near the edge of the eyelid in form of a flap, the base of which is at the edge of the lid. Then the mass of scar tissue is separated from the remaining tissue of the lid. This must be done very thoroughly and the resulting wound surface must be freed carefully of all roughness and shreds of tissue.

If at all possible hemorrhage is first completely stopped and then the adjacent skin mobilized and drawn over to cover the defect (if necessary relaying incisions through the skin must be made). On the whole skin transplantation is usually necessary, either in form of single or double pedunculated flaps from the surroundings, or non-pedunculated flaps from other regions. Both methods have a number of advantages and disadvantages, with which the reader is familiar.

In general, the employment of a pedunculated flap from the cheek is advisable for the reconstruction of the lower lid, in case there are no deep scars in the cheek; for the upper eyelid it is advisable to use a non-pedunculated flap, in order not to make the lid too voluminous or heavy. The very justifiable fear of subsequent formation of puffs after transplanting pedunculated flaps can be avoided by making it impossible for the flap to roll up. This is done by suturing the middle part of the flaps firmly to the substratum and by suturing the edges of the flap to the surrounding skin in such a way that the deeper parts of skin and subcutaneous tissue which are especially prone to roll up are uniformly spread out and kept under slight tension. To do this the suture is passed deeply through the wound surface and only superficially through the epidermal surface.

In employing non-pedunculated flaps or the Thiersch graft, it is important that they be transplanted sufficiently large and in a state of maximum contraction (they should therefore be prepared on the day preceding the operation and then left in place). They should be spread out on the wound without being stretched and their edges should be inserted under the surrounding skin to keep them from slipping.

Total loss of the upper lid gives the greatest trouble and makes the loss of the eye practically inevitable. New upper lids can be constructed by pedunculated flaps but they are without musculature and the best that can be hoped for is enough of a retaining wall to aid in the support of an artificial eye. No satisfactory result can be obtained in the upper lid unless the levator is functioning. Reconstruction of the whole thickness of the lid varies in the upper and lower lid.

If there is no total defect and the lid has merely been torn off from the inner commissure it is usually found as a rapidly shrunken and more or less shapeless, rolled-up mass below the temporal canthus. Even when there are many adhesions one should try to detach and replace the lid. To do this, it is necessary, however, to mobilize the base of the remnant of the lid by lengthening the palpebral fissure (after blepharotomy) and the scar of the tear (about 3 cm.) with diverging incisions; by loosening the flap thus formed and displacing it as much as possible toward the nose after that careful and firm suturing of not only the tip near the internal ligament but also of the whole lower edge of the flap at short intervals to the periosteum of the orbital margin.

The employment of a pedunculated flap according to Fricke demands special consideration in reconstruction of the lower lid. The wound surface should either be epithelialized previously (Eversbusch) or should be accomplished by implanting a prothesis covered in the Thiersch grafts or flaps of mucous membrane. Success is more certain when the skin covering the scar is used, or if that is not sufficient, in conjunction with skin from the adjacent portion of the upper part of the cheek. A vertical incision is made downward about 1.5 cm., connecting the incision with the lower convex curve, peeling off of the thin skin with a broad scalpel beyond the termination of the scar and as far as the conjunctiva bulbi. This flap is then twisted upward and fixed with several mattress sutures at the fornix and the upper edge of the flaps, thus forming the lid.

Special attention also should be paid to the fixation of Fricke's flap. In the nasal corner of the eye attachment should be made to the inner ligament, if possible with the posterior part and the periosteum. For this purpose Kuhnt splits the tip of the flap into a thicker posterior and superficial anterior layer and unites the first with the ligament, the second with the skin.

Dieffenbach-Szymanowski's method may be used by varying it for each individual case and combining it with the transplantation of a skin-cartilage flap from the ear to the wound surface.

Kuhnt however thinks the following method more suitable than the two just mentioned: The remnant of eyelid is used in conjunction with a bridged flap 2.5 to 3 cm. broad taken from the immediate adjacent skin of the upper part of the cheek. This is properly raised, sutured with its lower edge to the periosteum of the orbital rim and padded into a skin cartilage flap from the ear according to the Büdinger-Birch-Hirschfeld method. The resultant defect is covered by lateral displacement of adjacent skin of the cheek or with Thiersch grafts.

Parts of the upper intact lid should never be used for the reconstruction of the lower as the upper eyelid is so vastly more important for the protection of the eye than the reconstruction of the lower.

Reconstruction of the upper eyelid is exceedingly more difficult because Fricke's flaps can be used in only a very limited way on account of their weight and immobility. Even when the eye, as is usually the case, is missing or shrunken, the cosmetic appearance requires sufficient opening of the palpebral fissure.

When the lower lid is intact the author repeatedly advises its transplantation. The marginal scar is excised, the tendons of the levator and Müller's muscle are secured in loops. Excision of the papillæ of the lashes of the lower lid and freshening of the intermarginal edge of the tarsus, then firm suture of the two wound surfaces. In order to have broad and perfect union and to avoid tension, the anterior layer of the eyelid and the fascia tarsi-orbitalia are incised below the tarsus from nasal to temporal orbital rim. A Thiersch graft is transplanted upon the gaping wound. If necessary these relaying incisions are also placed in the remnant of the upper lid. After one or two months the new palpebral fissure is formed, if possible in the lowest part of the tarsus. The wound surfaces are then covered with narrow strips of mucous membrane from the mouth and later a border of eyelashes is tattooed onto the edges of the new upper and lower eyelid.

Landolt's method, as previously mentioned, may also give good results in that the lower lid is split up into a skin-muscle and tarsus-conjunctiva layer. The conjunctiva of the upper fornix is then loosened from the scar and united with the line of incision in the lower lid. One should then wait a few months so that the stretched tissues will no longer show any tendency to shrink and the new palpebral fissure is then formed.

If the eye has been lost or there remains only a small phthisic bulb, but the orbital portion of the upper lid is still preserved, reconstruction may be attempted with a bridged flap taken from this portion. The wound surface is covered by drawing down the mobilized fornix or, better still, with a skin cartilage flap from the ear and interposition of a cartilage segment also from the ear.

In the case of extensive wounds and cicatrices, especially those following cordite burns, much more radical methods are sometimes necessary in order to give the patients physical and mental comfort and to humanize the aspect of their faces. Under such conditions the gross flap transplantation of Tagliocozzi, known as "the Italian method" or the spectacular plastic introduced by Snydacker (*Amer. Jour. Ophthal.*, July, 1919, p. 529) and modified by Morax and others, which utilizes the skin of the neck in a long flap, furnish the only possibility of operative relief.

Esser in the *Annals of Surgery*, March, 1917, described a revolutionary method for enlargement of the conjunctival sac and lid-reconstruction among his "Studies in Plastic Surgery of the Face." The method he detailed at that time follows:

"The enlargement of the conjunctival sac is very often required to make room for the eye prothesis. In these cases the eyelid skin is then cut parallel with the eye slit, higher or lower according to the case; generally scars must be taken away. And now, after lifting the upper part of the cut, an impression can be taken (best with the assistance of a dentist) with sterilized wax material. This, after hardening, is carefully surrounded in the manner described with very thin Thiersch graft, which is then placed in the wound, and closed with pressure.

"The mould must be made in a manner and with such pressure that its size is such that afterwards, on sewing the wound together, sufficient tension results. Before cutting the Thiersch, which only takes place when everything is prepared to receive it immediately, without first placing it in a physiological solution, the hollowed mould must be placed in the hollow and the incision pressed together with the fingers, to see if the tension is correct, otherwise the mould can be altered. It is not practical to enlarge by adding to it, as the appropriation leaves a line where the Thiersch later on falls in, but it is better to make a new mould if the first prove too small. It is possible to decrease the size if too large, by cutting before it is quite hard and softening down the cuts.

"Closing under pressure by the sewing is necessary for two reasons—first, the Thiersch is pressed everywhere for quick healing, and second, possible bleeding is prevented. Though I construct the hollows by cutting on purpose to open the largest possible number of little blood- and lymph-vessels (by all free transplantations, I prefer this method to the blunt preparation in general use, because it gives better healing condition). By sewing together under pressure, the small vessels are all closed—only the large arteries must be squeezed or twisted, but not tied, as no foreign substance may remain between inlay and wound. In consequence of the pressure a primary healing of the suture is not sure, but mostly of less importance as an ugly scar can be easily corrected afterwards. After about two weeks the conjunctival sac is cut parallel to the eye split, and at such a distance from it where the inlay is nearest to the surface. The mould is removed and the smoothly healed hollow is annexed to the eye hole in order to receive the eye-prothesis, which must be placed directly so that the still elastic hollow can adapt itself to the prothesis form. It is now clear that the hollow must be constructed everywhere as near as possible to the mucous membrane."

In one case reported by Esser, where the inlay did not sufficiently approximate the conjunctiva, the opening into the epithelialized cavity closed and the operation was a failure.

Butler (*loc. cit.*) states that, in his opinion, the chief sphere of this operation is in cases of severe burning, when the surrounding skin is parchment-like and flaps cannot be obtained. Its advantages are that the graft invariably takes because it is subject to pressure against the surface to which it will adhere and it is kept warm and moist. Again it allows a free liberation of the contracted area and is usable when older procedures are inapplicable. Its disadvantages are that the cosmetic effect is mediocre; the graft has a wrinkled, parchment-like appearance and some depression remains. Again the edges are apt to be hard and obvious and to call for subsequent excision.

Butler gives further important details of the method: An incision is made along the lid-edge as already described. The skin is so undermined that a pouch is formed. A piece of "dental stent" or "dental molding wax" is warmed and molded till it fits into the pouch easily after covering it with egg albumen. An epithelial skin graft is now sewn around the stent, which is put into the pouch and the edges of the pouch are united by 4 or 5 sutures. In from 7 to 10 days the wound opens spontaneously or is opened and the stent removed. The pouch will be found to be lined with epithelium. It gradually unfolds, liberating the contracted lid. Among the important details is the fact that the dental "stent" is spoiled by boiling but is still good enough for our purpose. We boil it in an enamel basin and with sterilized fingers mold it to size and lay it down in a sterilized towel placed on a table provided with a chair of suitable height. On the table are placed needles threaded with thin catgut, needle holder, and conjunctival forceps. Molding wax is easier to use, but it can not be boiled because it melts to a film which floats upon the water. It must be softened in warm water, molded into shape, and sterilized by immersion in an aqueous solution of bioxide of mercury 1:500. An alcoholic solution tends to dissolve the wax.

The graft which must be about 1¼ inches square, is cut from the flexor surface of the forearm, arm, or from the inner aspect of the thigh. The arm must be flexed or the muscles will stand out and the cut will be too deep. The surface is made flat by the use of 2 thin boards with well squared edges, each about ¼ inch thick. A sharp razor is employed, a stream of saline being poured over its edge as it cuts. The graft must be thin and should not include any subcutaneous tissue. The graft is now laid on the sterilized towel and spread out with raw surface downward. The "stent" is placed on it and the graft sewed round it with fine catgut. Conjunctival forceps are convenient for this. The line of sutures must be placed so that they lie toward the outside when the "stent" is placed in the pouch.

When the unfolding is complete it may be necessary to excise the edges which sometimes remain hard and raised. It is necessary to make the original incision long enough to allow the pouch to flatten out easily, otherwise a pit will persist and a second operation be necessary to unfold it. When the graft has to be placed vertically at the inner canthus, a secondary intervention is generally needed to complete the unfolding.

The Esser technic is perfectly easy to acquire, but experience is needed to determine the most suitable shape for the "stent." A flat crescent seems best for a mold placed above or below the lids. "Stents" with a round cross-section tend to deep pits with incomplete unfolding.

The above is an outlay. An inlay is used to place grafts in the conjunctiva to remedy contracted sockets.

Esser's technic has been successfully modified by Waldron and by Gillies. Waldron, quoted by McKee, (*Canadian Med. Assoc. Jour.*, Feb., 1918) makes the incision in the conjunctival sac instead of through the eyelid skin; an impression compound mould is made, covered with the skin graft and buried in the manner described, except that over the mould are sutured the cut margins of the conjunctiva. He suggests undercutting the tissues of the cavity a little so as to make the cavity somewhat larger than the desired enlargement of the sac, and also suggests that in many cases it is found difficult to make the incision close to the tarsus. In making an inferior fornix he overcomes this by making the incision outwards and slightly downwards for a distance of one cm. from the external canthus. This modification has the following advantages, in his words:

"1. Unnecessary scarring of the eyelids is prevented and the normal elasticity of the skin not impaired. As it is not uncommon to have an accumulation of serum develop around the buried graft, sutures may give way and slight infection may take place without impairing the success of the graft. These minor complications, however, in the case of inlays buried through an incision in the eyelid skin, may lead to granulations and scarring, and in rare instances epithelialized fistulæ have developed necessitating operative excision and closure.

"2. The exact position of the new fornix may be better outlined by an initial incision through the conjunctiva than by the undercutting to a point just beneath the surface of the conjunctiva. In our experience, the fornix may be made closer to the tarsal plate by incising through the conjunctiva.

"3. The depth and direction of the cavity can be readily determined according to the necessity of the individual case."

Gillies in a masterly article (*Trans. Ophthal. Soc. U. Kingdom*, Vol. xxxviii, p. 70) on plastic operations on the eyelids, deals mainly with his use and modifications of Esser's method. His first modification consists in the graft covered mould being buried in the subcutaneous tissues of the eyelid through an incision in the skin and is removed through that incision. By this method the eyelid skin is increased to the extent of the graft. This is especially useful in contractions following burns. The second method may be termed an epithelial overlay. Here, extensive undercutting may be necessary before the remains of the eyelid can be brought to the normal position and the covering in of a graft covered mold is impossible. "After the remains of the eyelid have been sewn in a favorable position, scars excised and an impression taken of the entire raw area, a Thiersch is then applied to the raw area and held firmly in place by means of the compound impression. This may be left in position for ten or twelve days. By this procedure the employment of pedunculated flaps may be avoided in many cases."

McKee details two cases in which this method was employed:

Pte. M. W. was sent to West Cliff for repair of his right socket to enable him to wear a glass eye. After the usual preparation, and under an anesthetic, an incision was made along the lid margin the entire length of the damaged third of lid, the edges were separated and dissection was continued to a depth thought necessary. The cavity was then fitted with a mold of sterilized dentist's compound and sutures loosely put in place through the lines of incision. When the compound had been pared to the proper size, a Thiersch graft was obtained from the arm and wrapped around the compound with the skin surface next to the compound. This was then placed in the cavity, which had been thoroughly dried, and the sutures were drawn so as to keep the compound firmly held within this cavity. Ten days later the stitches were removed, the compound taken out, the graft had united entirely, the desired line of the lid had been repaired and the patient able to wear a glass eye.

Spr. W. M., service of Captain W. E. Ainley, with left anophthalmos, was unable to wear a glass eye on account of the shallow nature of the lower conjunctival cul-de-sac. Line of incision along the lower conjunctival sac was made, an epithelial inlay set in, on compound and sutured, the compound was removed ten days later, the epithelial inlay had entirely taken and made the wearing of a glass eye a simple matter.

McKee declares that results obtained in extensive ectropion following burns, by the epidermis outlay, technique of Gillies, are most satisfactory. "Equally so are the results obtained by the epidermic method of Waldron in injured lids and in shallow and distorted conjunctival sacs. The development of military ophthalmology along these lines has been extensive. The repair and even the reformation of the whole lid as well as the repaïr of the conjunctival cul-de-sac by the Esser, Gillies and Waldron methods, marks an epoch in ophthalmic surgery."

Gillies' epithelial outlay is, roughly, the converse of the inlay. His first idea was to insert it from the mucous membrane side and to remove it from the skin side of the lid which would be the exact converse to the treatment for entropion conditions but the necessity for the complication of inserting it from the mucous side was not apparent so it was inserted from the outside and the mold removed from the same incision.

For ectropion of the upper lid Gillies makes a curved incision just above the lid margin. This is deepened slightly, but not down to the tarsal plate and care is taken as far as possible to avoid interference with the levator palpebræ superioris muscle. To a certain extent the flap of skin lying above the incision between the incision and brow is undercut. This undercutting is continued until the lid margin descends to a lower level than normal.

A mold is then taken of this cavity, covered with skin graft in the same way, and the skin united again at the original incision.

When the skin is thus sewn up again over the mold the ectropion is more pronounced for the time being until the mold is removed. This incision is not tightly closed, so that there are one or two gaps in it which allow the new epithelium to grow around the margin of the incision. In some of the cases the incision has been reopened and the mold removed on the 10th day. The lid now drops below the normal level and the ectropion is permanently cured.

Where there is no hurry in removing the mold the incision gradually opens of its own accord, save for one or two bridges of skin easily divided without anesthesia. After the mold is removed there is no doubt as to the cure of the ectropion, but if a nice edge has not been produced, there is the appearance of an epithelialized ulcer, which, however, in the course of time softens with massage and the natural movement of the lid. The outlays in the upper lids give a very neat appearance in some of the cases, imitating very naturally a normal lid.

This has been successfully applied to such conditions as burned eyelids, in which, in order to give the eye a chance, it is necessary to get the upper lid over the cornea, a result being possible of attainment in from 5 to 7 days.

In cases of burns, where the outlay method is not altogether applicable, Butler urges that immediate grafting should be used in order to prevent contraction. When the burned surface has become clean and covered with healthy granulations, a thin and purely epithelial graft is cut and carefully spread over the raw area where it is covered thickly with vaseline, above which is a dressing of oiled silk beneath another layer of vaseline. When this dressing is removed at the end of ten to fourteen days the graft has usually grown and has become almost invisible.

Plastic operations of the orbit prior to the war consisted mainly in covering the deficit in the malar and orbital regions with a transplant of fat behind a sliding flap, or in using a Wolff graft. The comparative frequency of the broad, mutilating injuries in this region early in the war, developed new ideas for the closure of the great naso-orbital defects, for building up the shattered orbital rim and for filling in the great sulci grooved in the side of the head and face by the tangential passage of high-velocity missiles and rough shell fragments.

Morestin (*Bull. de l'Acad. de Med.*, May 23, 1916) suggested the use of a cartilage transplant for repairing orbital breaches, skull defects, the lower jaw and other points where a stiff and durable substance was required. He found the costal cartilages best adapted for the purpose, especially the sixth, seventh and eighth costal cartilages from the same or another person. He fills the breach with scraps of cartilage or the cartilage entire, sometimes leaving arms to project beyond. No suturing is required; the suturing of the soft parts above holds all in place. The perichondrium surface is turned inward as this side is apt to curve. The fragments blend and grow together and grow solidly to the adjoining tissues. By the end of a few days the gap is thus filled with a solid mass, and the skull or other bone seems regular and solid. Morestin thinks that the cartilage persists as such, as he has seen no evidence of ossification. His experience in the repair of war wounds has confirmed his assertions during the last two years that cartilage is the easiest of all tissues to transplant, and the best of all for purposes of repair where a light skeleton is sufficient.

Lagrange (*loc. cit.*) gives three methods for repair of the orbital walls (a) metallic plates, (b) fat grafts and (c) cartilage grafts. He states that in beginning such work he frequently attempted too much at one sitting but that his procedure finally became standardized to a preliminary blepharoplasty, followed about six weeks later by the necessary implantation of cartilage and fat.

In general orbito-plastics are performed (a) to close off broad communications between orbit and nose or maxillary sinus; (b) to replace larger defects of the bony orbital wall and (c) to fill up the orbital contents when these have been forced down into the nose or the antrum. As for the closing of broad communications with nose or maxillary sinus, after the sinusitis has cleared a pedunculated flap should be formed with the base of the pedicle as high as or a little below the bony ridge of the orbit. Then comes incision through the soft tissues down to the bone, where periorbita is loosened in the whole circumference of the defect. The flap is then twisted around and back so that the epidermidal surface faces the nose or the sinus. The edges of the flap are sutured to the periorbita or the periosteum of the nose. At the end of 10 days the pedicle is severed.

For the partial replacement of the osseous rim of the orbit both transplantation of a periosteal bone flap from the frontal bone or the body of the malar bone may be used for transplantation of a suitable flap of fat and fascia lata.

When broad destruction of the lower or inner wall of the orbit has taken place and the contents of the orbit have been forced down into the nose or the maxillary sinus, it is usually impossible to replace them. Nevertheless some filling for the orbit has to be devised in order to avoid severe disfigurement and to form a support for the prothesis. Attempts at transplantation of fat tissue under the conjunctiva gave just as unsatisfactory results as those made in order to flatten out the upper fold. Satisfactory results were to be had by first severing the outer commissure and the conjunctiva and then transplanting broad, thick, cone-shaped flaps with narrow pedicle from the side of the cheek and the forehead. It is necessary, however, that the flap be chosen sufficiently long and that the cone-shaped end be securely fastened to the periosteum near the inner corner of the eye. As soon as the transplants are definitely healed in, their pedicles are severed and the outer corner of the eye is reunited after the manner illustrated by Davis.

When the malar bone has been lost, the temporal muscle, swung forward, makes an excellent bed upon which to make a later graft of a cartilaginous orbital ring, as suggested by Gillies. It imparts rotundity to the cheek and gives a sense of real expression owing to the action of the temporal muscle in its new situation.

Gillies makes the economical suggestion that if more cartilage is excised in the initial operation for orbital reconstruction than is needed at that time, the remainder should be buried subcutaneously in the abdominal wall, where it will be easily accessible for future work.

III. Hopeless or Inoperable Sockets and Facial Defects.

The cases in which wounds or the depredations of disease have been so severe as to remove them beyond the range of even the most advanced plastic surgical operations unfortunately have not been rare. Derwent Wood (*Trans. Ophthal. Soc. U. Kingdom*, Vol. xxxviii, p. 102) at the time of his report in May, 1918, had treated about 100 such cases. In his technic a cast is made of the patient's face in plaster of Paris. All wound cavities are filled up with dressing and cottonwool, and these in turn covered with goldbeater's skin. The nostrils are blocked with cottonwool, the patient breathing through the mouth; if through the nose a quill is inserted for breathing throughout this operation. It depends on the area of wound as to whether nose or mouth breathing can be allowed during the process. Having obtained the mold and dried it slowly the next stage is to French-chalk it and take from it a clay or plasticine squeeze, which provides a positive model of the patient's healed wound and the surrounding normal tissue surface. This model is further developed by means of sittings of the patient, and this stage is completed by taking another cast—a negative.

The task now is to reconstruct the destroyed feature or features from the model taken from this negative mold, by building them up to match the corresponding or adjoining features of the patient, or from prewound photographs, taking the utmost care the whole time to keep the adjustment of the edges to the patient's face-planes. A cast is then taken of this; further manipulation is required for the fitting of an artificial eye (if the case includes such); a last comparison with the original is made, and the mask, in plaster, is complete. From this an electrotype plate is deposited. It is of pure copper, $\frac{1}{32}$ inch in thickness. The necessary fitments for glass eye and attachments are fixed, and it is finally well covered with an electric deposit of silver. The last adjustments are now made to the patient's face, the securing of the plate to the face being carefully considered. The attachment is usually made by means of strong spectacles, but spirit-gum and ribbons have sometimes to be used, varying with the character of the wounded area. Everything depends on the efficiency of the attachments in the matter of comfort to the patient, which is necessary in such cases, so that his attention shall never be drawn to his deficiency unless necessarily. The adjustment must be exact, therefore, and the edges of the plate can in no case be allowed to part from the sections of the patient's skin with which they coincide.

The plate has now to be pigmented to match the complexion of the patient. A thin coating of cream colored spirit enamel forms a good basis for the subsequent flesh color matching, as it leaves the oil color mat when dry, which facilitates the blending of plate with face. If the patient has an oily or shiny skin a semblance is easily obtained by varnish rubbed down to match. The eyebrows are painted to match and the eyelashes are made of thin metallic foil, carefully soldered to the plate, cut finely by scissors, and tinted to match. Renewal of the pigmentation must be made from time to time, however, for scar tissue changes the contour of the face, and readjustments must occasionally be made. If these changes are very great a new plate may have to be substituted for the original. The exquisite results of Derwent Wood's work are too elaborate for the majority of these cases who require an apparatus which is easy of adjustment and repair.

To supply the need for so simple an ectoprothesis, Rollet (*Arch. d'Ophtal.,* xxxv, 3) has had constructed a one-piece prothesis with orbital margins, lids and cilia which fits exactly into the depression corresponding to the orbit. This is made of a paste of water 25. glycerine 62. glue 5. pure white gelatine 20. to which some yellow is added to give it the color of the skin. When ready the paste is varnished with a mixture of ether 15. mastic 15. canada balsam 2.50. The patient makes his own prothesis by heating the paste and pouring it into a mold previously fashioned from his own orbital depression.

Adam (Abstr. *Ann. Ophthal.,* Nov., 1917, p. 594) makes a glycerine-gelatine casting mold to serve as a prothesis in these large defects but unfortunately these last only a limited time and have to be replaced frequently.

Coulomb and Ruppe (*Ann. d'Ocul.,* cliii, 4) replace the eye, the lids and the region about the orbit by a prothesis of vulcanized rubber which they found superior to metal, porcelain, celluloid, gelatine, etc., on account of its ease of handling, color and lightness. Ramsey also uses vulcanite. It can be molded with care and painted to harmonize with the surrounding parts of the face. The parts to be replaced are modeled in wax from which a plaster of Paris impression is taken. The soft rubber is then molded on the plaster of Paris, and vulcanized. The artificial eye is cemented to the vulcanite lids. After these have been colored to match the neighboring parts, the prothesis is attached to a spectacle frame.

In the A. E. F. every case of maxillofacial injury which required extensive repair was recorded abroad in some detail and these records corelated with the later records here at home. At certain centers abroad, photographs, casts and wax models were made of the earlier conditions, and tracings of the roentgenograms. At each of the four centers in this country there is attached to this service an artist, a sculptor, a photographer and a stenographer, and an officer is assigned to supervise and assemble the records. The Surgeon-General has sent out instructions as to the general plan of these records, and has ordered that on completion of the work all should be sent to Washington to be assembled with the records from abroad, for a permanent exhibit in the Army Medical School Museum. Part of this record is on exhibit in the Exhibition Hall here.

The matter of making masks to camouflage these face injuries was investigated extensively by the Surgeon-General, and a personnel trained for the work. A few were made for our soldiers by the Red

Cross in Paris, and several here, by our own staff; but the men will not wear them, preferring plastic reconstruction. According to Blair (*Jour. A. M. A.*, Aug. 2, 1919) there is not a single mask in use by our soldiers, and Major Gillies of the British service states that the soldiers there have the same preference.

THE RELATION OF MILITARY INJURIES OF THE SKULL AND BRAIN TO OCULAR AND VISUAL DISORDERS.

The fundamental considerations of the local and remote effects of military injuries of the skull and brain, especially in their visual and ocular reflections, of the surgical treatment of such injuries and of their common sequels are described at length in Vol. X of this *Encyclopedia*, pp. 7778-7812, under the above caption.

Further confirmation and elaboration of the basic facts there noted follows under the headings:

I. *General Considerations.*
II. *Classification of Cranial Wounds.*
III. *The Significance of Swelling of the Optic Discs in Projectile Injuries of the Cranium.*
V. *Disturbances of Visual Association.*
IV. *Visual Defects following Cranio-Cerebral Wounds.*

I. *General considerations.* The unprecedented use of high explosives and machine guns, the greater degree of exposure of the head in trench warfare and the universal employment of steel helmets, which lessen the mortality in head injuries while vastly increasing the number of scalp and cranial wounds, have been the main determining factors in the increased frequency and severity of wounds of the skull and brain seen in this war.

The experience gained from the study of many thousands of such cases has unified the surgical opinion that: 1. The majority of deaths among the cases of cranial wounds which survive long enough to reach the dressing stations occur from meningitis and encephalitis; 2. Immediate and systematic surgical intervention, done in so far as possible during the few hours before mere wound contamination gives place to active infection, affords the greatest, if not the only, chance for recovery; 3. The most detailed preliminary dèbridement is fundamental in the majority of the cranio-cerebral wounds, which, in common with practically all wounds, should be given the chance of union by primary suture; 4. Fundamentally correct surgery is followed by late sequels and residual infirmities much less often than is commonly believed.

The great number of cranio-cerebral wounds, representing 16 per cent. of all battle wounds, and their importance has led naturally to a monumental literature, much of which is epochal and among which the works which stand out as of the greatest ophthalmologic importance and which are freely drawn upon in the consideration of the subject which follows are those of Wilms (*München. med. Wchnschr.*, Oct. 19, 1915) establishing the principle of dèbridement in these cases; Roberts (*Brit. Med. Jour.*, Oct. 2, 1915, p. 498) and Gray (*Brit. Med. Jour.*, Feb. 19, 1916), who urged the routine use of local anesthesia in this form of cranial surgery; of Uhthoff (*Klin. Monatsbl. f. Augenh.*, July-Aug., 1915), Pierre Marie (*Bull. de l'Acad de Med.*, Nov. 16, 1915), Lister and Holmes (April 1, 1916, p. 485) and Gordon Holmes (*Med. Press,* Dec. 26, 1917) on military hemianopias and the cortical projection of the retina; Harvey Cushing (*Mil. Surgeon,* June, 1916, p. 601) and (*British Jour. Surg.*, Apr., 1918, p. 558) standardizing surgical procedure in cranio-cerebral military injuries; and of Riddock (*Brain,* 40:15, Part 1, 1917) and Holmes (*Brit. Med. Jour.*, Aug. 16 and Aug. 23, 1919) on disturbances of the ocular associative tracts.

Cushing declares that the imperfect training of general surgeons in brain surgery, together with the diverse and confusing forms of treatment which were urged were responsible for the early lack of unanimity of opinion as regards the principles of treatment of cranio-cerebral injuries. *The surgeon cannot tell what have been the surgical results in the past of methods differing from his own, nor can he tell whether his own percentage of recoveries improves as time goes on, without the vital interpretation of methods given by case histories and operative and terminal statistics.* Early in the war searching tests showed the folly of expectant treatment in cranial injuries of military origin, demonstrated that the bad repute of cranio-cerebral operations, from the standpoint of infection, is delay in transportation and showed that the long stay of such cases in the resuscitation wards is often dangerous where the effect of cerebral contusion is confused with shock, the condition in many of these head cases showing no improvement until the clotted blood and edematous and pulped brain which cause the symptom of pressure are removed. This critical analysis of results led to the operative methods most generally accepted as productive of the best end results: excision en bloc, under local anesthesia, of the contaminated scalp wound with the contaminated cranial wound, painstaking removal of clots and devitalized brain by alternate irrigation and suction through a flexible soft rubber catheter inserted into the cerebral track of the missile, the withdrawal of bone fragments, thus detected, by fine forceps and of the projectile and its fragments by magnet extraction, wherever possible.

Finally, this method of evaluating end results has been the means of encouraging further operative work of this nature, the careful studies of Sargent and Holmes in a series of 1239 cases and of Tuffier and Guillain of 6,664 cases which had recovered after trephining, showing that late sequels such as epilepsy, insanity, delayed abscess, crippling paralysis and other infirmities are far less common than is supposed to be the case.

II. *Classification of cranial wounds.* The classification of cranial wounds given by Cushing is followed as being fully comprehensive, the neurological lesions being stressed in this rather than the type of cranial fracture, which formerly held the main attention.

Cranial wounds are graded according to the existence of a fracture, the integrity of the dura, the presence of local or diffuse cerebral contusion and hemorrhage, the inclusion of a foreign body, penetration of the ventricles, involvement of adjacent air cavities and finally, of massive injuries. The main elements concerned in intracranial infection are dual penetration, extrusion of brain substance, penetration of the ventricles and exposure of the cranial fossæ to infection from the nose, inner ear and orbits.

(1) Wounds of the scalp, with intact cranium and dura and occasionally with an underlying contusion, had a mortality of 4.5 per cent. in the 250 cases of cranial injury operated upon by Cushing.

Many scalp wounds which appear serious prove to be trifling while more which appear trifling prove to be serious. Hence even among the walking wounded every scalp wound must be regarded as a potential penetrating lesion of the brain. Even radiograms often fail on lateral view to disclose slight depressed fractures, while irregularities of the skull, particularly those along the mid-vertex, may be mistaken for fractures. It is impossible to examine neurologically, to radiograph and to operate upon all cases in times of pressure and many severe cases undoubtedly are evacuated under these conditions as ambulatory.

Some of the most seriously lacerated scalp wounds are apparently produced by the helmet, for when this is guttered by a large missile the incurved metal edges may plough through the scalp like a harrow and cause extensive lacerations.

The essential feature of scalp wounds is not the condition of the scalp or skull but the condition of the underlying brain, hence, un-

less disproved by investigation, a fracture may be supposed to underlie every scalp wound made by a projectile.

(2) Wounds producing local fractures of variable types, with the dura intact, but associated with local contusions of the brain or extradural extravasation, are fairly common and gave a mortality of 9.2 per cent. in Cushing's series.

In warfare, while most fractures are compound and are caused by projectiles, many extensive fractures of the skull result from falls, from burial or from the secondary missile effect given to the helmet by the impact of a heavy projectile.

In this group the inner table may be intact or not, regardless of the condition of the outer table. If there is no infection of the scalp or other parts of the wound, there is no reason why the dura should not be excised if, after a careful toilet which includes the removal by irrigation and suction of blood clot and pulped and devitalized brain, the dura is promptly closed by silk sutures. Much less reparative reaction is necessary and where the disorganized brain has been left to care for itself there is a tardier convalescence and a slower restoration of function. The consequences of not opening the dura when local symptoms indicate the presence of a contusion is well shown by one of Cushing's cases who sustained a guttered bullet wound 8 cm. long extending from the right frontal eminence backwards and towards the middle line. He was knocked down but not made unconscious. Severe headache followed with numbness and weakness of the left side. He reached the dressing station with aid, and was admitted to the hospital three hours after injury. The radiogram showed "depressed fracture with linear fissures radiating backward toward the vertex and occiput. Small metallic fragments at site of depression." The optic discs were edematous, with obliteration of the cup, laminæ and nasal margins. Right pupil larger than left; tendency to conjugate deviation to the right. Weakness of the left arm, leg and face, without sensory loss. Deep reflexes brisk and equal. The scalp wound was excised under the usual novocain anesthesia eight hours after the injury, disclosing a depressed area from which many linear fissures radiated. Bloc trepanation showed fragmentation of the inner table and much depression. The dura was intact but extradural clots were removed with partial closure of the wound. Two days later lumbar puncture was done and clear fluid withdrawn as the left arm had become more helpless. General condition good. Two days later, however, repeated attacks of focal epilepsy appeared chiefly in the shoulder-girdle muscles, associated with turning of the head and eyes to the left. Paralysis of the left arm became complete. Extensive subconjunctival ecchymosis appeared. The wound healed well and remained in good condition but the focal epilepsy continued and slight numbness of the fingers and occasional twitching of the left face persisted, leading to a final discharge as permanently unfit.

In another case the radiogram failed to show a fracture beneath a scalp wound in the midline of the occiput, caused by a shell fragment. Operation, however, disclosed a depressed gutter fracture of the outer table, directly over the torcula and, on trepanation en bloc, a widely depressed area of the inner table was found with fragments indriven to a depth of 1 cm. but with intact dura. Closure without drainage led to an uneventful recovery by primary union and without hemianopia or visual disturbance resulting.

(3) In local depressed fractures of various types, with puncture of the dura, local contusions are inevitable and are usually associated with positive neurological signs, although cerebral extrusion is not common. This group furnished a mortality of 11.8 per cent. among Cushing's cases, the low rate being occasioned by the fact that despite meningeal puncture or tearing by a projecting spicule of bone, and even regardless of more or less gross contamination of the scalp wound, the comparatively intact mosaic of bone fragments interposes itself between the external wound and the brain and thus makes extrusion of the brain uncommon. Usually both tables are depressed, though this is not invariable, for the bone may be merely fissured or scored. It is not improbable that many fractures of this type remain unverified, particularly when the lesion overlies the mid-vertex and is accompanied by the so-called longitudinal sinus syndrome (Vol. X, p. 7798), in the presence of which Sargent and Holmes have advised against trepanation.

In the ordinary occipital injury of this type the usual neurological evidences of an injury of this region appear as complete central blindness and sharply cut hemianopia, either of which may be transitory or permanent. These lesions will be considered in greater detail under the head of *Visual defects following cranial wounds.*

Frontal wounds of this type do better, on the whole, than the occipital ones, despite the mental disturbance which may accompany the former and the tendency of the patients to disarrange their dressings.

(4) Wounds chiefly of a tangential type with dislodged fragments of bone which have penetrated the brain substance always show severe local contusion with almost inevitable extrusion of the brain. Fungus cerebri and encephalitis are common sequels, and were the main cause for the mortality of 24 per cent. in this group of Cushing's cases.

By far the greatest number of these tangential wounds are bullet wounds and occur over the parietal area or its junction with the frontal or occipital fields; 27 such injuries were parietal, 8 occipital and 3 frontal out of 38 reported by Cushing. The helmet had been perforated in most cases and the wounds were mainly single. The greatest single factor in the outcome of these cases is whether the ventricle has been penetrated or not. As the majority of these cases lie over the parietal vertex many are accompanied by grades of what has been called the longitudinal sinus syndrome (Sargent and Holmes, *Brit. Med. Jour.*, Oct. 2, 1915, p. 493), an immediate bilateral spastic paraplegia which resembles the birth-palsy of Little, affects the lower more than the upper extremities and whose symptomatic effects are attributed mainly to circulatory stasis, and partly to the bilateral cerebral contusion. The great majority of the fatalities which occurred in this group of Cushing's cases were among the occipital wounds, abscess formation, meningitis and gas encephalitis being the direct causes of death.

A case of this form of injury occurred in a disoriented man who believed that he had been wounded two days previously, when going over the parapet. He was stuporous but could be roused to answer questions. Pulse 60; severe headache and vomiting. The eyes were almost closed by edema of the lids and subconjunctival ecchymosis. The right posterior parietal region showed a circular, ragged, foul wound about 3 cm. in diameter, from which brain substance extruded. The radiograph disclosed a fracture with a cranial defect and five indriven fragments of bone. The right pupil was the larger and the fundi presented a low grade of papilledema with obscuration of the nasal margins. It was impossible to test for hemianopia. There were no paralyses and the plantar reflex was normal. There were no abdominal reflexes.

At operation, about 48 hours after the injury, the scalp wound was excised and bloc trepanation showed a dural laceration with a diameter of about 2 cm. through which the fungus cerebri protruded. Suction and irrigation of the track, with removal of the bone fragments from the depths of 5 to 6 cm., gave complete relief of pressure. The fungating portion of the brain was excised and the scalp incisions closed in layers. Smears and cultures showed bacilli of the aërogenes capsulatus type. Two days after operation the general condition was excellent. A sharply-cut left homonymous hemianopia was now demonstrable and this remained as a permanent defect up to the time of his evacuation about 3 weeks later. At this time the wound had healed, without tension.

In another case a soldier was struck by a fragment of shell which perforated his helmet causing a dirty 7 cm. transverse gutter wound crossing the midline of the occipital prominence. He was knocked down but retained consciousness. When seen 5 hours later he had central blindness and could not perceive a flash-light. The dura over the right occipital lobe was found lacerated at operation, with much pulping of the lobe. Disorganized tissue was removed thoroughly by suction and irrigation and several deep bone fragments and pieces of the helmet-lining were removed. Bleeding from the sinuses prevented a complete operative toilet. Some initial improvement occurred associated with enough visual clearing so that light objects and blue colors could be recognized, but meningitis supervened and caused death. Autopsy showed a cerebral fungus protruding from the right occipital lobe, severe contusion and pulping of the left occipital lobe, in spite of an intact overlying dura, and extensive meningeal infection.

5. In penetrating wounds with retention of projectile and bone fragments in the brain, the symptoms depend upon the size and course of the missile as well as upon the implantation of pathogenic organisms on the lodged projectile.

Many of these injuries herniate and the initial deep infection, the deep contusion and destruction along the track and later superficial infection of the fungus are responsible for the high mortality of 36.6 per cent. Many of the smaller indriven fragments are unquestionably well tolerated but that far more cases will recover after a rightly conducted operation than if left to their own salvation is the final and well-grounded operative dictum. Cushing states "Some go so far as to advocate withholding operation altogether, for unquestionably many of the smaller implanted fragments are well tolerated and such local infection as may occur may be successfully overcome without operative intervention. Indeed, in our series of unoperated cases, there were several with a penetrating projectile, all of which have done well. On the other hand these particular cases would have done equally well with a local operation and the risks they took would have been lessened. I have come to this opinion not only because of the numerous examples of abscess which have developed in unoperated cases sent to the base but also because of the many instances in this particular series in which death occurred from a small abscess at the end of a tract which after ten days or two weeks broke into the ventricle."

The cerebral lesions which may occur are so multiform that no neurological subdivisions of much, if of any value, can be made. The tracks made by the missile vary from those a few centimeters in depth to those which completely traverse the brain without emerging; or the missile may rebound from the skull and take a new course in the brain one or even more times, making intracerebral tracks in as many different directions before it lodges. The trauma may be fatal or negligible, depending upon the course of the missile, its size and injury to blood vessels or other vital structures.

This group is mainly temporal and prognosis of temporal wounds is distinctly better than of occipital.

Cultures made from lodged projectiles nearly always show that they have carried organisms of more or less pathogenicity into the tissues.

In the following case penetration was deep enough and the damage sufficiently severe to injure the geniculo-calcarine pathway. The square missile punched its way through the squamous wing and carried the bone fragments with it: A shell fragment passed beneath a helmet and caused a penetrating wound 3 cm. above the right pinna with brain extrusion. The X-ray showed a large missile 5 cm. deep and a fracture of the squamous bone. There was weakness of the left arm and face, deflection of the tongue to the left; left homonymous hemianopia; deep reflexes active on the left with a positive Babinski, but barely elicited on the right side. About 18 hours after the injury and with the use of novocain anesthesia a square, punched-out window was found in the squamous wing, with the bony fragment corresponding to the defect lying 3 cm. deep, and the missile, a 5 grm. copper driving-band of a 4.2 shell lying 3 cm. deeper. Magnet extraction failed and the missile was removed by a duckbill forceps. The track was cleansed by suction, irrigation with dichloramine-T and the wound closed without drainage. Perfect healing of the wound kept pace with clearing of the upper quadrants of the hemianopic fields. On the sixth day 3 focal epileptiform seizures occurred on the left side, beginning in the hand, but improvement progressed to evacuation on the eleventh day and ten weeks later to the written statement that the man was free from all symptoms and was quite well.

The *cerebellar penetrations*, though rare, were as favorable as the temporal penetrations, the sole fatality in six cases arising from gas-bacillus infection.

In a typical case, a shell fragment passed under the helmet, penetrating the right suboccipital region and lodged 4 cm. deep below the mastoid process. Characteristic right cerebellar symptoms resulted in the form of vertical and lateral nystagmus, coarser to right; incoordination of part of right side and both arms and legs; exaggeration of the deep reflexes without clonus; dorsal toe-response on left; deafness in right ear. A 1.8 grm. fragment of shell was removed by magnet. Evacuated to England 17 days later with cranial wounds healed by first intention but with some nystagmus persisting. Ataxia and headache and also right deafness continued.

Holmes (*Brain*, Vol. 40, p. 500) in a discussion of the alterations of ocular movements and nystagmus occurring in acute cerebellar injuries says: "For some days after a unilateral gunshot wound of the cerebellum the eyes while at rest are generally deviated towards the opposite side, especially if the patient happens to be unconscious, and at first it is often difficult to make him move them conjugately towards the injured side. When he attempts this, the range of movement is occasionally incomplete, but usually a more striking feature is its slowness and the effort necessary to execute it. In one patient at least in whom it was carefully investigated this conjugate paresis was associated with erroneous projection towards the homolateral side. The paresis diminishes gradually but the difficulty in movement to this side, in comparison with deviation in the opposite direction, frequently persists for weeks. The vertical movements of the eyes and convergence are never similarly affected.

"In five cases the position known as 'skew-deviation' was observed; that is, the homolateral eye was directed downwards and inwards while the other looked upwards and outwards. Nystagmus is less constant and less regular on vertical movements. Finally, on convergence both eyes often tend to deviate away from the side of the lesion and are brought back to their proper position by irregular jerks of small range. The nystagmus also tends to become less regular and less rapid as fixation tires, but it can be evoked again by renewal of fixation, especially if the object is moved slightly farther from the middle line. This is the characteristic form of nystagmus produced by recent cerebellar injuries, but divergences from it are common.

"Nystagmus of cerebellar origin is therefore characterized by the facts that it occurs chiefly on fixation, that the slow phase is always towards the primary central position or the 'rest point,' and that it is more constant, more regular, better sustained, and the oscillations of the eyeballs are slower in rate but larger in amplitude, when the patient looks towards his injured side."

But two of Cushing's seven cases of occipital penetration recovered, the deaths being associated with sepsis. In one of the cases which recovered, a shrapnel ball (weight about 11.7 grms.) penetrated the mid-occipital region 3 cm. above the protuberance, leading to extrusion of brain substance. The radiogram showed a fracture with indriven bone and a shrapnel ball near the mid-line, about at the top of the tentorium.

A right homonymous hemianopia and some obscuration over the left fields was found. The right arm, leg and face were weak and hypesthetic. The deep reflexes were over-active; no clonus; normal plantar responses. The dura, at operation, was found penetrated just to the left of the sinus which was uninjured. The track, 8 cm. deep in the occipital lobe, was sucked clean and many indriven bone fragments removed. The ball was palpated by the catheter but extraction was tried unsuccessfully. A perfect recovery had taken place two months later aside from a right hemianopia, complete for the left eye but involving the upper quadrant only in the right eye. This gave him little trouble. In a similar case seen in consultation by Cushing six months after having received the wound which had left a hemianopia, there seemed no reason for intervention. Six months after this consultation, however, an epileptiform attack led to the discovery and evacuation of an abscess cavity which had formed about the ball.

In one of the parietal penetrations a massive fracture of the skull followed a wound of the posterior parietal region, with such widespread, radiating fissures that crepitus could be obtained almost anywhere over the left side of the head. The fundi showed vitreous hemorrhages which obscured the disc on the left; right papilledema; apparently complete loss of central vision. The missiles could not be reached and the wound became infected. Fungus cerebri resulted with symptoms of abscess, presumably about the retained missiles. These were seen lying in the temporal lobe from which they were removed later, by magnet, after forming an abscess which was evacuated. Cultures from the wounds at this time showed diplococci, coliform bacilli and b. Welchii in abundance. The convalescence was stormy, the symptoms being referable to the incompletely treated track, but healing occurred after the free use in the wound of dichloramine-T, and seventy days after injury the patient was evacuated with healed wounds but with persistent left hemianopia. About three months later the fields had widened, the vision to the left was still defective, but barring this visual fault there were no other residual symptoms.

The deaths in the four fatal cases of occipital penetrations reported by Cushing were from gas abscess in the occipital lobe; spreading encephalitis, with complete disintegration of the right occipital lobe; streptococcic meningitis, sinus thrombosis and ventriculitis and in the last, apparently on the road to recovery from acute tetanus of the bulbar type.

6. This class of cases includes cerebral lesions of the types met with in groups 4 and 5 but their gravity is profoundly altered by the involvement of the ventricles through their penetration or traversal by fragments of indriven bone or by projectiles. The ventricular fluid escapes and hemorrhage into the ventricle is common. In Cushing's series 48 per cent. of these cases in which the ventricles were penetrated by bone died from the associated lesions or infection while the death of all of the cases in which the injuring factor was a projectile was due largely to the infection which was carried into the ventricle by the missile.

The most serious complication of brain injuries is the opening or traversing of the ventricle by the missile or by fragments of bone. All surgeons have emphasized the fact that *the prognosis in head injuries, in so far as infection is concerned, rests chiefly on whether or not the dura is intact.* Minor punctures of the dura, however, are not accompanied necessarily by a bad prognosis for, contrary to the view generally held, a fatal meningitis which spreads from the area of penetration is comparatively rare. Still more serious are the lesions in which fragments, often soiled, are driven into the substance of the brain and, if not completely removed, leave an infected track with swelling and extrusion of the edematous brain through the dural opening and external wound, the all-too-familiar fungus cerebri. In the course of time either the suppurative process finds its way into the ventricle or the advancing fungus distorts the hemisphere and draws out the ventricle which ruptures into the infected track. Both results are equally grave, but of far worse prognosis appear to be the penetrating wounds which, regardless of their point of entry, have opened the ventricle primarily with practical certainty of infection of the cerebro-spinal fluid at its very source. This condition is usually noted at the resulting autopsy.

A case of extraction of a fragment of shell from the infected ventricle by magnet two days after injury is worthy of note: The missile had penetrated the helmet to enter the cranium 2 cm. to the right of the mid-parietal vertex. The radiogram showed a projectile in the mid-brain and bone fragments along the track. A left spastic hemiplegia involved the arm, leg and face and with associated sensory loss over the arm and leg. Clonus at knee and ankle; dorso-plantar response; left homonymous hemianopia. Optic discs hyperemic, with blurred outlines and edematous cups. The wound of entrance was excised, much disorganized brain and clot escaped. A soft catheter entered the ventricle at the depth of 6 cm. and about 20 cc. of bloody seropurulent fluid came away. A culture of this yielded abundant b. Welchii and staphylococci. Eusol irrigation into the ventricle brought forth several fragments of bone from the track, after which a 3.8 grm. fragment of projectile was extracted by the magnet, a nail being passed into the ventricle as a magnetic vehicle. Repeated cultures from the escaping fluid showed a persistent infection with cocci and b. Welchii in abundance and accordingly gentle irrigation into the ventricle was done through the soft catheter daily. Twenty-six days later the track into the ventricle had healed and a puncture into it, in search for a possible abscess, disclosed clear, sterile fluid. The patient died from inanition, as may happen to bed-ridden hemiplegics. This case is advanced by Cushing as support for his contention that in head cases the long period passed in the resuscitation ward with the administration of heat and stimulants is too serious a loss of time when considered from the standpoint of the possible establishment meanwhile of a serious infection. A cranial operation under combined morphia and local anesthesia may be carried on at the same time that the shock is being combated.

In another case of ventricular penetration the patient was profoundly unconscious on admission, with a pulse of 60 and complete right hemiplegia. The right pupil was dilated and the right disc showed 2 D. of swelling. Operation showed a film of clot over a very tense hemisphere. At autopsy the track of the missile was shown to have passed from the frontal pole of the hemisphere into the left ventricle, which was distended by blood and contained a 2.2 grm. projectile about opposite the posterior end of the thalamus. The entire left hemisphere was contused and edematous.

Another case, admitted 24 hours after injury, was dull and disoriented. A small penetrating wound of the left occiput was found, through which brain extruded. A radiogram showed the missile in the parieto-frontal region in the mid-line. Papilledema and a right homonymous hemianopia existed.

At operation the missile was found to be too deep for extraction and streptococci were discovered in the lumbar fluid.

At autopsy the 0.5 grm. fragment of shell was found to have passed from the tip of the occipital lobe through the left ventricle and falx to lodge in the right frontal lobe. The ventricle was found infected and a basilar meningitis coexisted.

7. Wounds of the cranio-cerebral type, which involve the orbito-nasal or auro-petrosal regions, are commonly associated with exposure and protrusion of the brain, with radiating fractures of the

skull, with breaches into the nasal or petrosal cavities, and the meningitis which is the common result of these complications is fatal in over 70 per cent. of such cases.

Penetrating wounds of the fronto-orbital type are illustrated by one in which a large fragment of shell perforated the soldier's helmet as he was mounting the parapet, causing a circular wound of the left frontal eminence, the fragment coming to rest in the orbit and its roof. The blind left eye was proptosed, ecchymotic and immobile and its pupil was dilated.

A radiating fracture of the frontal bone was found by trepanation en bloc done with local anesthesia. A large opening in the dura was occluded by stinking fungus. The missile was removed by the magnet, the track cleaned by suction and irrigation, and the entire pulped tip of the frontal lobe and several bone fragments being removed. An opening was found about the size of a ten cent piece through the roof of the orbit with crushing and infection of the orbital fat. Gas bacilli and staphylococci were found in the culture and dichloramine-T was used in frequent irrigation. Every second day for ten days lumbar puncture was used to collapse the cerebral hernia sufficiently to expose the opening into the orbit and permit drainage. A month and a half later the patient was evacuated, after a gradual subsidence of the hernia and healing of the wound beneath a graft. It is likely that in this case immediate enucleation, followed by direct drainage through the orbit would have given a more rapid and less broken convalescence. Another case of orbito-fronto-cerebral penetration is made interesting by reason of the development of delayed tetanus a month after injury, despite having received a preventive injection of 1000 units when injured. A 53.2 grm. missile had passed beneath the helmet, had lacerated the left upper lid and frontal region, had passed through the supraorbital ridge and had become so securely wedged in the orbit as to require general anesthesia for its removal. The roof of the orbit had been torn away, widely exposing the base of the frontal lobe from the site of the supraorbital notch through the frontal sinuses and inwards to the anterior ethmoidal region. The collapsed globe was enucleated. An oculo-motor paralysis of the uninjured eye appeared on the tenth day but the protruding brain healed over and convalescence seemed well established when, 34 days later, tetanus developed, but was speedily overcome by specific treatment. At the time of discharge, 3 months later, normal movements had been regained in the right eye.

8. Perforating or "through-and-through" cranio-cerebral wounds are so commonly associated with extensive damage to the skull and

brain as to lead to death from intracranial hemorrhage and compression in about 80 per cent. of such cases. Certain of these cases, however, escape without the least disability and the experience is not unique, of a clean perforation of the fronto-temporal region without even momentary loss of consciousness or other disorder save a transitory headache.

9. Bursting fractures with widespread cerebral contusion commonly provoke compression phenomena and give a mortality of about 50 per cent. They are best relieved by a properly conducted cerebral decompression.

Logre and Boutier (*Paris Médical*, May 24, 1919) recognize that the varied war traumatisms affecting the brains of strong young men set up a special reaction evidencing the autonomy of traumatic mental pathology and the marked difference between this and all other modes of diffuse psychopathic reaction such as emotions, mania, melancholia, toxic-infectious confusional states, etc. The dissociations induced have a decided diagnostic value and form a guide to treatment, especially in the line of surgical neuropsychiatry. This special pathology determines the remote prognosis by the modifications more or less profound and durable in the entire personality which may be entailed by the diffuse cerebral microtraumatism. The mind gives evidence of mental paresis corresponding to what in the muscles is lax or spastic paralysis, with or without ataxia. There are no hallucinations, no tendency to ataxia; the trouble is in the intelligence and the affections. The anatomic processes responsible for this mental paresis are generally paralleled by changes in the cerebrospinal fluid, an albuminosis with dissociation or inversion of the albumin and cell count. This may subside or last for weeks or months. Toxic-infectious injury of the brain, that is, a chemical lesion of the brain, manifests itself in a set of symptoms of the confusional type. Diffuse traumatic injury of the brain, that is, a mechanical lesion of the brain, manifests itself in the mental processes as a kind of sluggishness in the mind, a mental paresis. An initial loss of consciousness is the rule with this diffuse traumatism from concussion of the brain. When there are localized wounds besides, the set of symptoms from the diffuse concussion and those from the localized trauma should be estimated separately, when they will serve as a guide to treatment, they explain in detail.

III. The significance of swelling of the discs in projectile injuries of the cranium. One of the most important functions of the ophthalmic surgeon is that of examination for eye signs in cranial injuries, and of these signs papilledema and papillitis are among the most significant.

In this connection the difference between choked disc and papillitis must be emphasized. The former is an expression of increased intracranial pressure and the latter of intracranial inflammation, although it is often impossible to make the distinction ophthalmoscopically, especially as the two distinct pathological forms not seldom coexist.

Normally there is a free communication, within the vaginal sheath, between the optic papilla and the intradural cavity which makes intracranial hypertension obvious in the fundus, especially in changes about the disc, and in the caliber and tortuosity of the vessels. Conditions favoring this pressure increase are present after shot wounds of the skull whether the dura had been wounded or not and all early swellings of the disc after such wounds are really choked disc.

A fracture of the skull is in fact a safety valve for the relief of the increased intracranial pressure, which, with the frequently associated hemorrhage, are hardly less important in terms of ultimate damage than infection itself. As Sharpe (*Arch. Ophthal.*, July, 1917, p. 320) clearly states, choked disc does not follow these injuries immediately for there is a period of four to six hours after the injury when, as the result of shock, the blood pressure is less than the intracranial pressure. Many cases die during this period of shock, but with its survival, the signs of increased pressure become manifest in the fundus, and at this time operative interference is likely to give the most favorable result. Intracranial hemorrhage and edema after these skull injuries rarely produce a swelling of the disc mensurable with that produced in the civil conditions of brain tumor, hydrocephalus or by the inflammatory papillitis, in which the slower progress of the lesion permit the brain and particularly the medulla to adapt themselves to the increased pressure with little immediate risk. The papilledema following shot wounds seldom exceeds 2 per cent. of projection while 1 per cent. or less is the average.

In many cases of traumatic intracranial bleeding and edema, and particularly in the absence of marked shock, the intracranial pressure rises so rapidly that the compensatory mechanism of the medulla has not time to come into play and adjust its vaso-motor and respiratory centers. Death may result in such cases before the development of choked disc is possible. Where the medulla can adapt itself to slowly increasing pressure, however, as in the case of extradural hemorrhage, measurable papilledema is the rule before death ensues. In favorable operative cases, the relief of extradural and subdural hemorrhage not seldom leads to so immediate a subsidence of the papilledema that within 24 hours a modest residual edema and a blurring of the details of the disc may be all that marks the previously grave condition. In such cases pallor of the disc may remain indefinitely but where intervention is early and successful there are no permanent defects of visual acuity, no deficit phenomena in the visual fields and no vascular changes. If stasis persists, associated with such other symptoms of hypertension as an increase in the pressure of the spinal fluid and the medullary compression sign of a lowered pulse rate, it is evidence that some intracranial lesion has been overlooked, the track imperfectly cleansed, or lodged and infected missiles have been neglected.

Ordinarily, if an operation is postponed until choked disc has occurred, not only is the ideal time for operation lost but the chances for recovery, or at least for recovery without grave sequelæ, are against the patient. This is in complete accord with Cushing's earnest plea for operation without the usual critical wait in a resuscitation ward at the time when infection may be developing out of simple contamination and when, coincidentally, the prolonged high intracranial pressure may be laying the foundation for the post-traumatic conditions of persistent headache, emotional instability of either the excited or depressed types, mental and physical lassitude, and, in rare cases, epilepsy in its various forms. The remarkable absence of such sequelæ in the experience of all adequately trained military surgeons who specialized in head surgery and who were enabled to operate without delay, is proof of the correctness of these fundamental observations.

With regard to operative intervention in any given case, however, the ophthalmoscopic appearance of the disc alone should be decisive only in exceptional cases.

The swellings of the disc which return or which appear months after the original injury are usually papillitis, the product of inflammation, which may or may not be combined with the edema of stasis. In any case they represent a grave intracranial lesion, usually of the type of abscess about a retained foreign body or an imperfectly cleaned track, meningitis or cyst. In these cases the significant factor is not the mere fact of the presence of the papillitis but its increase. Changes in the visual fields or in the visual acuity are seldom of great aid in determining the question of operative procedure under these conditions, it being well recognized that even considerable degrees of swelling with abundant hemorrhages about the disc may not reduce the visual acuity greatly, even after relatively long periods, while involvement of the optic radiations and retinal cortex in the abscess zone, although not unknown, is rare.

Prosthetic surgery of the cranium should be deferred as long as any sign of papilledema or neuro-retinitis persists.

It is also a clearly established fact that there is no constant relation between the side of the injury and the eye first or more affected with disc changes or with the frequent pupillary inequality, now recognized as a sympathetic phenomenon arising from meningeal irritation.

IV. Visual defects following cranio-cerebral wounds. A research of the visual fields is necessary in all cases of occipital and parieto-occipital trauma, regardless of their apparent triviality, for in this region occur the most characteristic and striking of all cranial injuries, the contusions and tangential wounds over the occipital poles which cause central blindness and all manner of permanent and transitory defects in the visual fields, and in the parieto-occipital areas, the lesions of the optic radiations and of the association tracts which affect the visual fields in the first instance, and the visual association tracts in the last, often in connection with deficits in the fields.

Penetrating and perforating injuries of the region between the occipito-parietal sutures almost inevitably produce permanent visual defects, the typical feature of these occipital injuries being that the principal defect is visual rather than nervous.

As has been stated in the previous essay on this subject (Vol. X, p. 7800) wounds of the occipital region are subject to the same surgical procedure as in other parts of the brain, with the possible exception that the removal of foreign bodies from this region is to be undertaken only with the most extreme caution and only through the wound of entrance, lest additional trauma augment the existing visual defect. The rule of trephining all cases where the bony skull has been so much as grazed by a projectile applies here and the excision of the wounds in scalp and skull en bloc, the use of irrigation and suction whereby the track may be cleansed, bone fragments and metal washed out or made accessible to delicate forceps or to the magnet through an intermediary iron core, the evacuation of clot and pulped and devitalized brain, and primary suture, are all as imperative as in the cortical motor areas. The external table is often intact in occipital injury, owing to the unusually firm texture of the occipital bone, and the true bony lesions often are displayed only after trepanation, when the inner table may be found fractured or even fragmented into small splinters which may press into the dura with or without rupture. Laminæ of clotted blood form between bone and dura and over the occipital cortex, which is always more or less edematous, the site of capillary or frank arterial bleeding or which is irreparably destroyed in the severe injuries.

Immediate unconsciousness, of momentary or of considerable duration, usually follows the injury, but when control returns, blindness of any degree may remain. Unless there has been a direct bilateral lesion of both visual cortical centers, the early, more or less complete, blindness which follows so many of these occipital injuries, gradually resolves into one or another form of hemianopia or scotoma, or, as in a few reported cases, into complete restoration of vision without discoverable deficit phenomena in the visual fields. In these cases of initial total or relative blindness the later restoration of vision depends upon the subsidence of the constant reactive edema of the contused cortex and subcortex, the absorbtion of cortical capillary hemorrhage, and the contraction and organization of meningeal clots.

The usual subjective symptoms which accompany these occipital injuries are headache and vertigo, in some cases visual irritant phenomena such as scintillating scotomata, ophthalmic migraine, disorders of visual orientation, loss or damage of the optical memory-pictures, hallucinations with closed eyes, and, in common with all cerebral injuries, those psychic dissociations probably induced by the diffuse cerebral microtraumatism originating from mechanical shock to the nerve elements, or to the effect of heightened intracranial pressure, too long unrelieved.

Before we consider the common objective disturbances a brief review of the visual tracts and pathways may be of value: The first visual neurones coming from the retina terminate in the external geniculate body, the anterior quadrigeminal body and the optic thalamus, from where association fibers run to the nuclei of the third nerve (pupillary innervation). The second visual neurones, forming the optic radiation of Gratiolet begin here and a lesion at this point causes homonymous hemianopsia with possible involvement of the nerves supplying the ocular muscles as well as the nerves of audition. The intracerebral optic fibers pass backward deep in the substance of the temporal lobes and along the internal face of the occipital. In the form of vertical laminæ of white substance, about 2 cm. broad, they follow the external wall of the lateral ventricle into the occipital lobe, where they terminate about the calcarine fissure and the adjacent portions of the cuneus above, and the lingual lobule below. A lesion just posterior to the thalamus in the internal capsule may cause hemiplegia or hemianesthesia as well as hemianopia without pallor of the optic discs. Pressure upon the optic radiation in its midcourse may cause homonymous hemianopia without other symptom. A lesion of the important association tract, the fasciculus longitudinalis superior, running from the calcarine fissure to the angular gyrus will cause hemianopia and the association defects of word-blindness, mind-blindness, word-deafness, alexia, dyslexia, paraphasia, stereognosis, disturbances of spatial orientation, visual attention and appreciation of movement. The recognized frequency with which injuries of the left association tracts are accompanied by reading-disorder and writing-disorder is explained by interruption of communications between the occipital lobe and the sensory speech center in the left temporal cortex. Destruction of the angular gyri and the neighboring structures, even with intact optic radiations, will, of course, produce complete mind-blindness. Destruction of the pole of each occipital lobe, the center of macular vision, will cause a central scotoma in the field of each eye. To recapitulate: homonymous hemianopia may be produced by disturbances of the visual fibers at any point between the chiasm and the cortex of the cuneus; if anterior to the thalamus, the discs are usually pallid (the hemianopic pupil-symptom of Wernicke has proven valueless as a localizing aid); when the lesion which causes the hemianopia involves the corpora quadrigemina as well, paralysis of the ocular muscles and deafness are likely to be present; a lesion in the optic radiation, if near the thalamus and internal capsule, is accompanied by hemiplegia of the same side and by hemianesthesia much less often; destruction of the higher cortical centers leads to mind-blindness, while damage to the optic radiation with the association fibers will cause hemianopia and dissociation of the visual associative functions.

It has been assumed, though apparently without sufficient foundation, that hemiachromatopsia indicates the involvement of a special color center. Hemianopia, however, may range in degree from a slight relative defect to an absolute defect. When the field is complete for large white objects, but defective for one or more colors, it has been found that the field is equally defective for such small white objects as have a field equal to that for each color in the normal eye. Holmes considers that it has not been conclusively shown that color perception may be completely lost in any part of the field, when that of light or white is undisturbed; many of the hemi-achromatopsias have been instances of hemiamblyopia. He frequently observed among his cases that red and green test objects could not be recognized in certain regions, often in homonymous halves of the visual fields. But in every instance visual sensibility to white test objects of the same size was reduced; his observations led him to the conclusion that an isolated loss or dissociation of color vision is not produced by cerebral lesions.

The hemianopias of civil life differ from those of military injuries in that they are nearly all directly or indirectly of vascular origin, and the occipital cortex and subcortex affected include a wedge or cone of tissue all of which becomes functionless and involved in the final massive atrophy; in the wounded, however, after the disturbances of commotion, bleeding and reactive exudation have passed, the final lesion usually remains very circumscribed. It seems wholly probable, however, that projectile and other traumatic lesions of the same vessels or vascular systems, the involvement of which produces the hemianopias of disease, must be instrumental to a large, if not preponderant, degree, in the causation of many of the cases of vertical hemianopsis, the essential civilian hemianopia, which are not rarely seen in these battle injuries, particularly after the deeper lesions. Further, the relative frequency of horizontal hemianopia, the characteristic form of battle defect, reported in civil literature up to 1913 in but two bilateral and four unilateral cases (Peter, *Ophthalmology,* Vol. IX, April, 1913), unlike the altitudinal hemianopias, has no peculiar vascular relation but represents direct injury to the occipital pole, which escapes in disease owing to the overlapping of the arterial supply of the posterior and middle cerebral vessels.

The frequent projectile injuries of the occipital region have contributed not only to our knowledge of the clinical varieties of deficit phenomena in the visual fields but, in a greater and more important degree have clarified the question of the cortical projection of the retina and its localization in the optic radiations.

The view is now quite generally held that the upper segment of the optic tract and of the external geniculate body corresponds to the upper quadrants of the retina, while the lower segment represents the lower retinal quadrants. In the optic radiations the upper bundle of fibers corresponds to the upper retinal quadrants, which are projected on to the upper lip of the calcarine fissure and the lower part of the cuneus, while the lower part of the retina is projected on to the lower lip of the calcarine fissure and the upper part of the lingual lobe. These conclusions, which were arrived at in part by Inouye from a study of a number of cases in the Russo-Japanese war and in part by Monbrun (*Ophthalmic Year Book*, p. 300, 1914) have been verified and amplified by numerous qualified observers such as Uhthoff (*loc. cit.*), Marie (*loc. cit.*), Lister and Holmes (*loc. cit.*), Beauvieux (*Arch. d'Ophtal.*, Jan. to Aug., 1917, serial), Morax (*Ann. d'Ocul.*, Vol. 156, p. 25), Morax, Moreau and Castelain (*Ann. d'Ocul.*, Vol. 156, p. 1), Brodman (*Munch. med. Woc.*, 1918, Vol. 45, p. 887), Hine (*Brit. Jour. Ophthal.*, Vol. 2, p. 12), and Holmes (*Med. Press*, Dec. 26, 1917). Holmes details the views now generally held concerning the segmental correspondence of different areas of the retina with separate zones of the cortical visual area as follows:

"1. The upper half of each retina is represented in the dorsal, and the lower in the ventral part of each visual area.

"2. The center for macular or central vision lies in the most posterior part of the visual areas, probably on the margins, and in the lateral surfaces of the occipital poles. The macula has not a bilateral representation.

"3. The center for vision subserved by the periphery of the retina is situated in the anterior portions of the visual areas, and the serial concentric zones of the retina from the macula to the periphery are probably represented in this order from behind forwards in the visual areas.

"4. Those portions of the retinas adjoining their vertical axes are probably represented in dorsal and ventral margins of the visual areas; while that in the neighborhood of the horizontal axes is projected on to the walls and the floor of the calcarine fissures.

"Severe lesions of the visual cortex produce complete blindness in the corresponding portions of the visual fields, or, if complete, an amblyopia, color vision being generally lost, and white objects appearing indistinct; or only more potent stimuli, such as objects moved sharply, may excite sensations.

"6. The defects of vision in the fields of the two eyes are always congruous and superimposable, provided that no disease or injury of the peripheral visual apparatus exists."

This last conclusion is subject to the modification noted by many observers and especially by Uhthoff who remarks that while the hemianopic defects are strongly symmetrical except when the eyes have become fatigued by the examination, the intensity of the functional disturbance is both absolutely and relatively different in the two eyes. Vinsonneau (*Clin. Ophtal.*, vii. 10) also notes the frequency with which the visual acuity is unequal in the two eyes in cases of traumatic homonymous hemianopia although the refraction, fundi and media are normal in each. The quality is reduced in the eye situated on the same side as the hemianopia, e. g., the right eye is the poorer in right hemianopia. He explains the 16 cases of the sort reported as being the result of difference in the size of the straight and crossed macula bundles at their occipital origin.

"7. Lesions of the lateral surfaces of the hemispheres, particularly of the posterior parietal regions, may cause certain disturbances of the higher visual sensibility, as loss of visual orientation and localization in space, disturbance of the perception of depth and distance, visual attention loss, and visual agnosia." The reason for these conclusions, as formulated by Holmes, will be discussed serially in the consideration of the various defects of the visual fields.

The main objective disturbances produced by projectile wounds of the occiput, particularly the contused wounds and the tangential or gutter wounds, are 1. simple occipital contusion; 2. cortical blindness; 3. horizontal hemianopia; 4. vertical hemianopia; 5. quadrantic hemianopia; 6. hemianopic scotomata and 7. irregular field defects. Morax, Moreau and Castelain (*Ann. d'Ocul.*, Vol. 156, p. 1, 1919), out of an experience of 86 cases, have further subdivided the hemianopic effects, with especial regard to relative frequency and to macular involvement into the seven following types:

I. Homonymous hemianopsia, 27 cases. A. Not affecting macular vision, 19 cases; B. Affecting macular vision, 8 cases.

II. Sector hemianopsia, 18 cases. 1. Inferior—A. Not affecting macular vision, 6 cases; B. Affecting macular vision, 8 cases. 2. Superior—A. Not affecting macular vision, 1 case. 3. Double inferior—A. Not affecting macular vision, 3 cases.

III. Hemianopic scotoma, 20 cases. 1. Median type—A. Without macular involvement, 1 case; B. With macular involvement, 4 cases. 2. Inferior sector—A. Without macular involvement, 3 cases; B. With macular involvement, 4 cases. 3. Double sector—A. Without macular involvement, 4 cases; B. With macular involvement, 1 case.

IV. Homonymous hemianopsia with hemianopic scotoma of the opposite side, 14 cases. A. Without macular involvement, 4 cases; B. With macular involvement, 10 cases.

V. Double hemianopic scotoma, 4 cases. 1. Median, 2 cases; 2. Inferior, 2 cases.

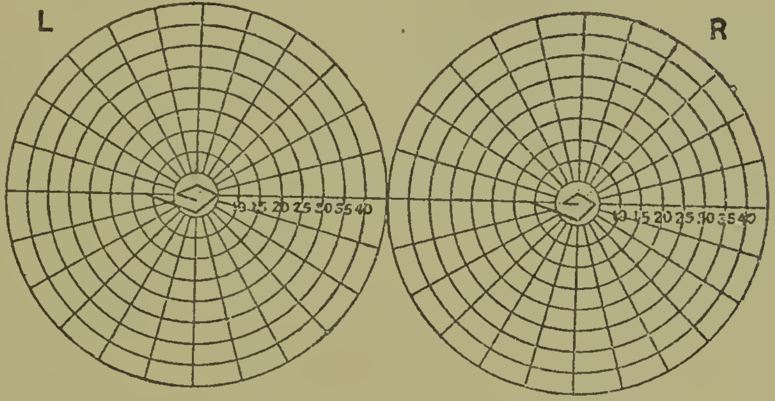
VI. Homonymous hemianopsia with central scotoma, 2 cases.

VII. Blindness, 1 case.

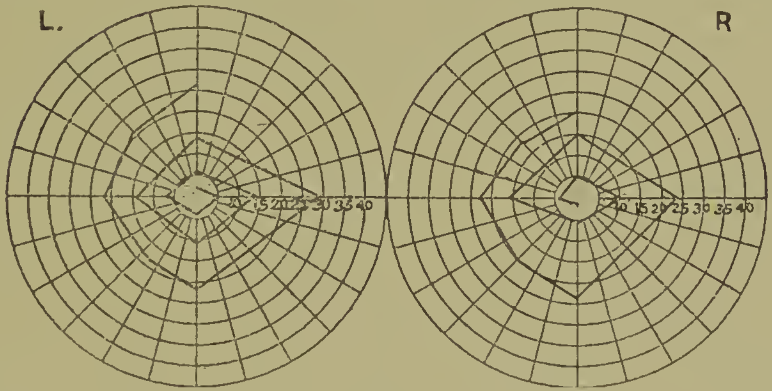
1. *Simple occipital contusion.* A considerable number of cases of occipital contusion are on record in which the initial symptoms which appeared grave and presaged permanent total visual loss or, at best, marked hemianopic defects, cleared without residual symptoms whatever within a few weeks. Probably many more cases of lesser traumatic disturbance have gone their way as ambulatory cases, unrecorded, to an equally happy result.

Where the skull exhibits a gross injury and the initial visual disorders have fully cleared, it is impossible to determine whether cortical edema or laceration, subdural or subarachnoid effusion, capillary oozing, or microtraumatisms are responsible for the visual fault. Quick recovery probably depends upon the existence of an edematous swelling of the areas concerned, analogous to that observed in the myelin sheaths of the spinal cord. Cushing (*Brit. Jour. Surg.*, April, 1918), provides a striking example to the point, in the case of a man whose helmet was perforated by a shell fragment which damaged the occiput. Immediate and complete blindness resulted. At operation ten hours after injury, a tear was found in the dura, beneath an intact pericranium and a stellate depressed fracture over the lambda. "There was no very evident contusion of the occipital lobes. Light perception began to return in 48 hours, after which the vision cleared very rapidly to normal. In every cerebral injury concussion and contusion play a part, and often a considerable part, in both the immediate and late symptom-complex which follows, and yet the anatomic findings are so inconstant that in some fatal cases the most minute investigation has failed to reveal anatomic lesions of any sort. In most cases of projectile injuries pure commotion is rare, however, owing to the tremendous speed of the missile, and the usual findings are capillary hemorrhages, minute cortical lacerations and the consequent disintegration of myelin. It is surprising, however, to see the amount of tissue change which may spring from even a feeble impact. Wilson (*Trans. Ophth. Soc. U. K.*, Vol. xxxvii, p. 92) details, as an example of cerebral concussion, a case of a soldier who was struck on the back of the head by a fragment of shell. He was unconscious for three minutes but was roused by the movement of his wounded arm. Blindness persisted for 48 hours but by the third day there was dim vision in each eye. No dysmetropia. Two months later the vision had become fixed at 6/60 in each eye; discs and pupillary reactions were normal and Jaeger 14 print was the smallest which could be read. The fields were concentrically contracted for white and for colors and so marked a condition of visual fatigue existed that excellent examples of helicoid curves were obtained in both eyes, not greatly different from two cases reported by Marie and Chatelin (*loc. cit.*) and one by Lister and Holmes in which the fields were clinically indistinguishable from those of hysteria, though as in these other cases, without a trace of the symptoms of a hysterical psychoneurosis such as the invariable cutaneous anesthesia which accompanies the hysterical neurosis. In Wilson's case the radiogram showed a splintered and a cracked inner table. Except for the visual symptoms there was no impairment of the functions of the nervous system.

Wilson raises the question of the relative vulnerability to concussion of the special sense systems of the cerebrum. He has no data for taste and smell. but in his experience visual impairment after generalized cerebral concussion is much rarer than labyrinthine impairment, and certainly rarer than auditory impairment. It is interesting to note in this connexion that Mott finds in his experience of "shell shock" cases that defects of vision are relatively uncommon as compared with deafness and hyperacusis. Probably the anatomical situation of the central vision apparatus acts as a protection, while the peripheral auditory mechanism is prone to be concussed for the same reason as the labyrinth.



Spiral Fields for Red in Concussion Injury of Occiput. (Kinnier Wilson.)



Spiral Fields for White in Concussion Injury of Occiput (From Kinnier Wilson *loc. cit.*)

Hine (*Brit. Jour. Ophthal.,* Vol. 2, p. 12) corroborates the observations of Holmes and others that the hemianopic faults seen in connection with concussion and contusion injuries, especially in the hemianopia due to slight parietal injuries, usually but not constantly, clear from the center to the periphery, while the scotomata caused by loss of cerebral substance gradually contracts from periphery to center as the surrounding edema of the brain subsides. Hine further notes, in the same connection, that the field of vision usually returns in the upper quadrant before the lower, and, in the writer's experience, never vice versa, this being due to the fact that all the injuries recorded here have been above the occipital pole, which is situated as a rule about one inch above the union. Hence, the occipital cortex above the calcarine fissure, which represents the lower part of the field of vision, has borne the brunt of the blow. Any injury below the occipital protuberance is much more likely to be fatal, owing to injury to the cerebellum and medulla.

The restoration of function at first is incomplete, but when once it has commenced it seems to proceed in a definite order—color perception coming after the perception of white, even though the colored object is the larger, and, as recovery takes place the appreciation of colors becomes more and more acute, so that small colored objects can be distinguished farther and farther away. By this means, in suitable cases, one can roughly measure, for clinical purposes, the recovery of function in the macular region.

Hence it is necessary when suspecting occipital cortical injury, to use small colored test objects as well as white, or else a partially recovered lesion may be missed, or lesser injuries to the cerebral cortex of the occipital lobe may be overlooked.

On the other hand, in the more slowly and steadily recovering cases with subdural or extradural hemorrhage, there would seem to be no such separation between color appreciation and appreciation of a white test object. This could be explained by supposing a less severe injury to the macular area, while only a careful comparison of the color fields from day to day could show whether they increased proportionately to the fields for white. Such examination would, however, in most cases be impossible or unreliable on account of the patient's condition.

Riddoch states that recovery of vision for movement begins in the periphery of the restricted field, a conclusion not fully concurred in by Holmes.

2. *Cortical blindness.* This appellation was originally given to that form of complete loss of vision which resulted from the total destruction of the visual cortices in both hemispheres, usually from a perforation of both centers by a bullet. Of late, however, the tendency seems to be to make the term apply as well to cases where injury to the visual cortex has left permanent defects in the zone of fixation, corresponding to about 10° around the macula. With equal logic the application could be applied to any manner of permanent defect of the visual field resulting from an injury to the visual cortex of sufficient

degree to be actually noticeable and disturbing. Accordingly it would seem more accurate either to limit the term to the condition of total blindness, as originally suggested, or to qualify cortical blindness as complete and incomplete, the latter including all the hemianopic and scotomatous defects, and as transitory and permanent, according to duration. It is probable that the looseness of application of this term has arisen from the relative frequency with which contusion-concussion blindness of this type has left a residual visual defect in the fixation zone alone, the limited defect coming finally to assume the term which was formerly applied to the whole defect at its onset. It is, however, possible that the marked disabling effect, in terms of vision, produced by the bilateral loss of central vision has further confused the meaning.

A deeply penetrating gunshot wound of the occipital region immediately to one side of the middle line, and not more than 5 cm. above the union, that passes forward parallel to the mesial sagittal plane, must destroy the whole of the area striata of one hemisphere. All such cases had complete hemianopia or total blindness to the opposite side of the fixation point. This blindness extends almost invariably up to the fixation point, or at least to within one degree of it, which is certainly within the margin of error of our clinical methods. The more accurate and delicate the methods employed, the nearer is the blindness found to come to the point on which the eyes are directed. Observations of an ordinary perimeter can not be exact enough to decide this question, but it can easily be verified by examination by a Bjerrum's or other screen which is placed at a distance of one or two meters from the patient's eye.

Holmes (*Brit. Med. Jour.,* Aug. 16, 1919, p. 194) illustrates a case of cortical blindness in a soldier who was wounded by a large portion of shell that penetrated his helmet in May, 1918. He was unconscious for 17 hours. In the casualty clearing station where an operation was performed the same day, a depressed fracture of the skull was found in the occipital region, and a mass of bone was removed from the longitudinal sinus and from the brain on each side of it. He was blind for the first three days, but his vision then rapidly improved to an acuity of 6/60 — in each eye. A month after the infliction of the wound his fields were examined by Mr. J. B. Lawford, who discovered a scotoma almost identical in size and position with that which Holmes found nine months later.

Ten months after the injury the wound was firmly cicatrized; beneath the scar there was a more or less circular defect in the middle line of the skull and to the left, which involved the base of the inion and extended 4½ cm. upward from it. Its lateral diameter was 5 cm. The vision was less than 6/60 in each eye (according to his records it was 6/6 when he enlisted in November, 1915), and he could not even recognize the other men in the ward. He saw nothing plainly and had difficulty in recognizing the distance of objects from him.

His peripheral vision was unaffected; he could see a circular white object 10 mm. in diameter to the natural limits in both eyes, but examination with a perimeter and by a screen revealed a large area of absolute blindness, which extended about 3 degrees to the left of the fixation point and from 12 to 18 degrees to its left. Central vision was completely abolished.

Above and to the left of this scotoma there was a small area in which white objects could be seen, but they appeared dull and dim; colors could not be recognized here, nor in a zone of about two degrees to the left margin of the scotoma.

The site of the wound makes it probable that both occipital lobes were injured at the posterior ends of the areæ striatæ, which were opposite the center of the trephine opening. Both the position of the wound and the clinical symptoms indicate that the injury was more extensive on the left than on the right side.

This case illustrates the type of blindness that is produced by superficial injuries of both occipital poles, that is, by wounds that injure the posterior parts of the areæ striatæ. In all such cases peripheral vision is found intact and central vision abolished. They are, consequently, evidence that central or macular vision is represented in the more posterior parts of the visual areas, and that this region is not concerned with peripheral sight.

The evidence to be obtained from unilateral lesions confirms this opinion and also supports the conclusion already arrived at, that the upper parts of the retinæ are connected with the upper parts of the visual cortex and the lower with the lower.

Cortical blindness in the limited sense of total permanent blindness is, happily, very rare, the occurrence of 1 case of the sort out of 86 cases of visual defects following occipital injuries in the series reported by Morax, Moreau and Castelain probably representing its approximate incidence among the injuries which survive. As the lesion which produces this defect is obviously relatively grosser than that which causes the usual hemianopias and other incomplete defects of the fields; there is little doubt that this severer form of physical injury has an actual incidence decidedly higher than is evident in the tables of results or in the hospital records.

In the extreme form blindness persists unmodified and, if vision of any sort remains or returns, it seldom exceeds a vague sense of luminosity or at best an exceedingly contracted field of distinct vision. In the lesser injuries total blindness or only light perception and the recognition of gross movement and form may exist from the time of injury, the vision returning gradually after days, weeks or even months. In the lightest forms the clearing of vision is complete but most often a methodical screen and perimetric investigation of the fields will reveal a residual defect, often so slight as to have been quite overlooked both by physician and patient, whose simple complaints are usually rapid eye tire and difficulty in reading. Care has to be taken to avoid fatigue in these examinations as Schiele and others have shown that prolonged examinations of the visual fields which show contraction in one eye seem to cause a retraction of like degree in the visual field of the other eye. The investigation should be suspended if the patient complains of fatigue. The typical fatigue spiral field associated with hysteria in civil experience has been found in cases of this sort by Wilson and others, but all the cases reported are devoid of hysterical stigmata and probably are the expression of organic injury of the visual centers. The discovery of residual defects is of the greatest importance to the soldier both as to his future incapacity and for the purpose of fixing his indemnity. A superficial examination misses the condition and acts seriously against the just claims of the handicapped man.

3. *Horizontal or transverse hemianopia.* The horizontal defects of the visual fields which follow occipital injuries are unique in civil experience, the literature up to 1913 having reference to but 6 civilian cases of the sort, one bilateral inferior hemianopia reported by Uhthoff caused by symmetrical disease of the optic nerves; another reported by Peter as due probably to gumma of the inferior part of the chiasm; unilateral cases reported by Russell, as due to a basilar bone tumor; by Sailer, as caused by rheumatic retrobulbar neuritis; by Krause, as the result of ethmoidal disease and by Peter as the product of embolism of the inferior retinal arteries. Twelve cases were reported from the Russo-Japanese, the Transvaal and the Chinese Boxer conflicts, and the large number reported from all combatant sources in the present war, a number which will probably total well over a hundred cases, indicate that this particular defect is peculiarly a military injury.

Holmes (*loc. cit.*) discussing the manner of production of these defects of the visual fields and their significance in relation to cortical localization of vision states: "Owing to the decussation of a portion of the fibres of the optic nerves in the chiasma, each optic tract conveys impressions from the same sides of both eyes—that is, impressions excited by the retinal images of objects in the opposite halves of the visual fields. And since each tract terminates in the primary optic centers of the same side, and the optic radiations that spring from here pass to the same side of the brain, a total lesion of any part of the one optic system above the chiasma produces hemianopia, or blindness in the opposite halves of the visual fields.

"It has only been within recent years that, as a result of many anatomical, physiological, clinical, and pathological investigations we have acquired any accurate information as to the region of the cortex where retinal impressions excite visual sensations. These investigations indicate that the visual centers lie within and along the lips of the posterior parts of the calcarine fissures, and that they probably correspond to that portion of the cortex characterized by the presence of Gennari's line, which Elliott Smith has called the area striata. In most brains this striate area extends around the occipital pole on to the lateral surface of the hemisphere.

"Until lately, too, we possessed very little evidence of the manner in which the different segments of the retina are represented in the visual cortex, but owing to the large number of cerebral injuries that have been produced by gun-shot wounds, the late war has given us an unequalled opportunity to investigate this problem."

Numerous observations by Holmes and others have provided fuller data for discussion, the evidence being partly clinical and partly the result of careful post-mortem study. In the latter form of investigation Marie and Chatelin used the method of fixing a brain in formol, after which it was removed from the skull and a leaden wire inserted along the whole length of the bottom of the calcarine fissure, while the optic radiations were marked out from the cortex inwards by small lead pellets. The brain was now replaced in the bony skull and radiograms taken antero-posteriorly and laterally, exactly as would be done in the case of patients with wounds in the skull. It then became possible to map the track or position of the projectile accurately with relation to the optic radiations and the calcarine area of the cortex by placing a tracing of such a radiogram over the patient's head. Holmes found it impossible to determine the portion of the brain that was injured merely by measurements of the sites and the depths of the wounds, a method which is inexact though the position of the area striata can be determined approximately in that the inion, or the external occipital protuberance has a fairly constant relation to its posterior end. In mesial sagittal sections of several heads Holmes found the posterior ends of the calcarine fissures lying 2 cm., or 2/3 in. above its tip, the fissures extending forward and upward at an angle of about 25° from there to a depth of about 4 cm. By careful measurement of the injury to the skull or of the position of retained missiles as seen in stereoscopic radiograms in relation to the inion, the portion of the visual area that is injured may be determined approximately. Further information was obtained in many cases by examination during operations of the site and extent of the damage to the brain.

As Holmes says, we must, however, await the opportunity of correlating the visual defects with the anatomical lesions that caused them in a large series of cases before finally receiving such conclusions as can be placed into the body of accepted fact, though if these conclusions establish an hypothesis that can explain all our observations, or is at least not in variance with them, there will be strong presumptive evidence that it represents the truth.

In hemianopia due to vascular lesions of the visual cortex the blindness rarely extends up to the fixation point, owing to the preservation of the macula region by vascular overlapping and in this respect it differs from that produced by a traumatic injury of one occipital pole in which the lesion is direct. The area of blindness is liable to be more irregular, and does not involve central vision so constantly, when it is due to injury of the optic radiations.

Inferior hemianopsia, or blindness below the fixation point, is found in soldiers with wounds above the occipital protuberance more or less in the median line, involving the occipital lobes above the level of the calcarine fissures in the upper portions of the striate areas. A lesion of one lobe in this situation produces an inferior quadrantic hemianopia, the bilateral lesion producing pure inferior horizontal hemianopia. Lesions of the right hemisphere cause left homonymous hemianopsia; while lesions of the left hemisphere cause right homonymous hemianopsia. To produce bilateral homonymous hemianopsia, a lesion of both hemispheres is necessary.

One of Holmes' cases was under observation for ten months after injury which was caused by a machine-gun bullet. The man was unconscious for a short time. During the first few days he could distinguish only light from darkness, but his vision then improved rapidly. Its condition became stationary after an operation was performed three weeks later in a German hospital, for he had been made a prisoner of war. He states that when he tried to read during the next three months he always seemed to see the figure of a white hen to the left of the point to which his eyes were directed.

When seen after release eight months later, the wound was represented by a healed and depressed scar, under which a trephine opening about 2 cm. in diameter could be felt. This involved the middle line of the skull; its center was 5 cm. above the inion. Radiographic plates did not reveal any foreign bodies within the skull. His central vision was 6/6 in each eye. There was a large area of blindness in both lower quadrants, which was more extensive on the left than on the right side, and in the seeing portions of the left lower quadrants vision was misty and indistinct. The injury to the brain was clearly above the level of the calcarine fissures and it was consequently the dorsal portions of the areæ striatæ that must have been most severely injured.

Holmes (*Brit. Jour. Ophthal.*, July, 1918, p. 363) details another case of the sort in which post-mortem examination was possible:

The patient was unconscious for some hours after having been struck over the occiput by a fragment of shell-casing. Later the vision was found greatly reduced but persons were recognized.

There was a small penetrating wound of entrance 7 cm. above the inion and 5 cm. to the right of the sagittal suture, while the exit, which had been operated upon, was much larger, with its center 10 cm. vertically above the tip of the left mastoid. When admitted to the base hospital there was marked loss of visual orientation in space; he was unable to recognize accurately the relative and absolute position and distances of objects by sight alone. This persisted until death and made an accurate exploration of his visual fields difficult. A full record, however, was obtained 4 weeks after the injury and subsequent perimetric observations showed no change. Central vision was 6/12 in each eye and Jaeger 1. Both lower quadrants were completely blind, the blind area terminating sharply at or just below the horizontal line through the fixation point. The blindness came to within 1 degree of the latter. In the right upper quadrants peripheral vision was restricted to about 50 degrees, and white and colored objects were seen less distinctly in the remaining portions of this quadrant, than to the left of the vertical line. The color fields were, however, normal in both upper quadrants.

This patient died from other causes seven weeks after the injury. On examination of the brain the entrance wound was found in the middle of the lateral surface of the right occipital lobe some distance behind the level of the parieto-occipital notch. From here the missile passed through the dorsal parts of the optic radiation and emerged on the mesial surface of the hemisphere in the angle between the calcarine and the parieto-occipital fissures. The track of the missile was small and it had produced relatively little softening around it. The missile then entered the mesial surface of the left hemisphere in the parieto-occipital fissure, the destruction it produced reaching to 0.5

cm. of the calcarine fissure, passed through the dorsal portion of the optic radiation, and made its exit through the anterior portion of the gyrus angularis. On this side there was a considerable area of destruction, especially beneath the wound of operation.

In this case the blindness in the inferior quadrants was probably due to destruction of the dorsal portions of the optic radiation, and the defect in the upper right quadrants to additional damage of the left optic radiations by the softening under the angular gyrus; but the fact that there was no restriction or amblyopia of the left upper quadrants, despite the presence of a lesion in the dorsal and anterior part of the right visual area permits the assumption that no part of this quadrant is represented in the dorsal portion of the calcarine cortex.

Superior hemianopia is much more rarely seen than inferior hemianopia, in that wounds involving the lower portions of both striate areas must, in most instances, cause such injury of the torcula as to be probably fatal at once or within a short time. Uhthoff saw but one case of superior hemianopia out of 30 cases of hemianopic visual defects occurring in 40 occipital shot wounds, while but one quadrantic case appears among the 86 hemianopic defects noted by Morax, Moreau and Castelain.

The following case of Holmes' is an example of a superior quadrantic hemianopia: A fragment of shell penetrated a soldier's helmet and produced a small defect in the skull just to the right of the midline and just above the lateral sinus. He was unconscious for but a few minutes and noted that his sight was affected when he recovered. The sight improved rapidly after an operation performed on the day of injury but difficulty in reading was still experienced when he was seen three weeks later. At operation an oblong piece of shell-casing which measured 3x1x1 cm., and several fragments of bone were removed from the brain, which was softened and disintegrated for a considerable distance beneath the fracture.

When he was seen three weeks after he had received the wound there was complete left superior quadrantic hemianopia, which reached exactly up to the fixation point, and in addition, a peripheral contraction of the left lower quadrants. The latter gradually disappeared, so that five weeks later vision was lost in the upper quadrants only. The blindness still extended up to the fixation point, but it did not everywhere reach the horizontal meridians; there was a narrow zone along these in which a small white object was indistinct and frequently not perceived. In the lower left quadrants white appeared grayish and the color of red and green test objects 10 mm. in diameter could not be recognized. Central vision was 6/6 in each eye.

Here we have a case in which a penetrating wound close to the middle line, immediately above the lateral sinus and consequently below the level of the right calcarine fissure produced an absolute superior quadrantic hemanopia. It is therefore evident that the lower halves of the retinæ are projected on to the lower parts of the area striata. The loss of color vision in the inferior quadrants was associated, as is the rule, with the slight degree of amblyopia there, which was indicated by the apparent indistinctness and greyness of a white test object in this portion of the field.

Destructive *injuries of the optic radiations* generally produce a complete hemianopia, in which the blindness may or may not reach the fixation point, or large irregular areas of blindness. Occasionally, however, the form of the visual defect is more regular, and such cases bear on the important question as to whether the fibres of the radiations that carry impressions from the retina and end in definite portions of the visual cortex are arranged in order according to the origin of the impressions they carry and to their exact termination.

In a considerable number of cases quadrantic hemianopias or other regular defects in the fields resulted from lesions of the radiations. The following two cases, in which direct injury of the calcarine cortex can be excluded, may be cited:

A man was wounded by a shrapnel ball. He became at once unconscious. On regaining consciousness he had much headache and was dull and stupid for some time. He found his vision was affected, and had difficulty in reading; this was, however, not due to his being unable to see the letters, but to the fact that he had to spell them out one by one. No other disturbance of speech was observed.

The wound was circular, about 1 cm. in diameter, just at the attachment of the upper margin of the left helix. An X-ray examination showed a whole shrapnel ball in the left temporo-occipital lobe, probably lying on the upper surface of the tentorium, a short distance within the skull; in a lateral X-ray view it appeared to be midway between the inion and the upper margin of the petrous bone.

He was first seen three weeks after the infliction of the wound. Then he had for a few days much headache, and ophthalmoscopic examination revealed a moderate degree of optic neuritis. The entrance wound was consequently explored, and some depressed fragments of bone were removed, one of which had penetrated the lateral sinus. From this time his condition improved, and his headache became less severe.

Examined six weeks after injury, a complete superior right quadrantic hemianopia was found, which with the screen scotometer was seen to come to 2½° from the fixation point, using a 7.5 mm. test object. In this case it is clear that only the lower portion of the optic radiations could have been injured, and their injury produced a pure superior quadrantic hemianopia.

In another case the missiles could have damaged only the right optic radiations and from their position it seems probable that only the lower fibers of these were involved.

In these three cases lesions of the lower parts of the optic radiations of one side produced superior quadrantic hemianopias and it must be assumed, consequently, that those fibers of the radiations which carry impressions from the lower retinal halves pass through the ventral sections of the optic radiations. These and similar cases lead to the conclusion that the fibers of the radiations are arranged regularly in laminæ or series according to the origin of the impulses which they carry. The defects of the fields are so frequently quadrantic, despite the gross nature of the injuries, as to suggest the possibility that even in the main mass of the radiations those fibers indirectly connected with the upper and the lower halves of the retinæ are contained in distinct bundles, separated from each other by an anatomical interval. The course of the fibers concerned with macular vision is still uncertain although some observations would suggest that they have a distinct path of their own, but no case of isolated central or paracentral scotoma has been seen attributable to a lesion of the radiation.

In the horizontal hemianopic defects in general the patients usually have more visual disturbance than is met with in the vertical defects. They often declare that their view is obscured by a film. Probably the frequent involvement of the macula in the defect is, in part, responsible.

4. Vertical hemianopia. The classical lateral or vertical hemianopias are most often caused by deep and usually oblique perforation of the posterior temporo-parietal region, by which the optic radiations, deep in the temporal lobe, are divided or injured. These cases are not usually preceded by cortical blindness. The hemianopic defect exists definitely from the moment of injury and visual disturbance is sensed. According to Marie (*Bull. de l'Acad. de Méd.*, Nov., 16, 1915) it is rare that this type of lesion results from direct lesions of the visual center in occipital wounds, for in that case, if the trauma is extensive, the lesion is bilateral and cortical blindness or inferior hemianopia result, or if the trauma is slight, the visual lesion is only partial and the homonymous lateral hemianopia incomplete.

Cosse and Delord (*Ann. d'Ocul.,* cliv., 2) report the case of a soldier who was wounded in the occipital region by a fragment of shell, but who, despite normal visual acuity, behaved like a blind man owing to the blotting out of three-fourths of his visual field by a right homonymous hemianopia complicated by a left inferior quadrantic hemianopia, leaving vision in the upper left quadrant only. There were no other neurological symptoms during three months of observation. The radiograph showed a depression in the median line of the occiput at the site of the trepanation and disclosed two spiculæ of bone, one on each side, localized according to the method of Marie (q. v.) above the visual centers at the tip of the occipital lobes. The injury of brain tissue must have extended to the upper margin of both calcarine fissures to give the extensive defect.

A case seen by Morax (*Ann. d'Ocul.,* cliv, 5) was injured in the right occipital region. His ocular symptom-complex included left homonymous hemianopia, neuroparalytic keratitis, and paralysis of the dextrogyrators. The hemianopia is explained by the presence of a large metal fragment at the level of the right occipital lobe and the keratitis by the action of a right cerebellar abscess, an extension of which affected the region of emergence of the trigeminus. The paralysis of the oculogyrators is due either to the traumatic cerebellar lesion or to the development of the abscess in such fashion as to affect the nucleus of the sixth pair.

It is of interest that despite the presence of a cerebellar abscess, as shown at autopsy, there was no nystagmus, no papilledema, fever, or other symptoms indicative of a cerebellar abscess. Genet (*Lyon Chir.*, Nov., 1916) reports 4 cases of hemianopia due to perforating wounds and accompanied by hemiplegia, aphasia and extrusion of brain. One case of occipital injury showed a large, unrecognized subdural hemorrhage at autopsy.

Morax also reports two cases of tangential occipital injury followed by hemianopia (*Ann. d'Ocul.*, cliii, 3) in which the symptomatic evolution pointed to a contusion of the occipital lobe and subcortical hemorrhage as the origin of the visual defect. He accordingly advised against operation on the ground that the condition could not be benefited by trephining. In view of the surgical progress since these cases were seen it is likely that there would have been some benefit from the operative removal of devitalized brain and of clot and possibly, in view of the notorious inaccuracy of the X-ray in this region, of fractured inner table. Certainly such measures in qualified hands could have been provocative of no further tissue insult.

Holmes (*loc. cit.*) reports a case which was unconscious for several days after injury. At the operation, performed on the day of the wound, a depressed fracture was found in the left occipital bone a short distance above the lateral sinus, and several fragments of depressed bone were removed from a deep track in the brain. When examined, six months after the infliction of the injury, the wound was represented by a circular trephine opening immediately to the left of the middle line of the skull, with its center 4 cm. above the inion. No foreign bodies or retained missiles were visible in the radiographic plates. His central vision was 6/6 in each eye, and he believed his vision to be as good as it had ever been; but he had an absolute right homonymous hemianopia, which came exactly to the fixation point. He was also completely blind in the mesial portions of the left lower quadrants except in a small area within three degrees of the fixation point. This blind area lay approximately between the inferior vertical meridians and the radii at 45 degrees from them. Vision for both white and colors was unimpaired in the remaining portions of the left halves of the fields.

In this case the right-sided hemianopia was obviously due to the deep penetrating wound of the left occipital lobe. The loss of sight in the left halves of the fields shows that the right visual cortex also must have suffered, and the position and the nature of the wound make it probable that the damage to the mesial surface of this hemisphere was superficial and probably limited to the surface of the cuneus. That portion of the area striata that lines the walls and the floor of the calcarine sulcus, and consequently lies farther lateralwards, probably escaped injury.

Holmes has seen many cases in which superficial injuries of the mesial aspect of the one hemisphere were associated with blindness along the vertical meridians of the visual fields. This suggests that the part of the area striata which is exposed on the surface of the hemisphere is concerned with vision in the neighborhood of the vertical meridians, while the visual cortex that lies more laterally in the walls and floor of the fissures is that which subserves vision along the horizontal radii. Wilbrand and Henschen's celebrated case, in which a narrow homonymous scotoma that extended from the fixation point horizontally outward to 60 degrees was associated with a softening of the floor of the fissure, is complementary evidence of this hypothesis. Holmes has not seen such a scotoma produced by a war wound but is not surprised thereat, as any missile which penetrated the brain to the bottom of the calcarine fissure would necessarily injure the fibers of the optic radiations that pass to other parts of the visual cortex, and consequently produce more extensive blindness.

Pincus (Abstr. *Amer. Jour. Ophthal.*, Aug., 1918, p. 138) studied 22 cases of occipital shot wounds in which optic neuritis was observed in only three cases. Eight of these showed the typical picture of homonymous vertical hemianopia. A case of optic aphasia and right-sided hemianopia did fairly well after the shot had been removed from the left occipital lobe. In a patient who presented peculiar fatigue symptoms, relatively dark portions of the visual field became absolutely dark during epileptiform fits. Five cases of inferior hemianopia of varying degree were noted, only one being the result of a typical cross shot.

Cushing (*Brit. Jour. Surg.*, April, 1918) reports a number of cases with hemianopia of the vertical order, one having lesions over the lateral sinus with damage to the cerebellum as well as to the occipital lobe. This case was injured by the passage of a fragment of shell beneath his helmet, producing a deep gutter wound behind the right mastoid. There was some bleeding from the external ear. A sharply-cut left homonymons hemianopia existed. The deep reflexes were brisk to exaggeration but no cerebellar symptoms were detected beyond a slight nystagmus. At operation 24 hours after the injury, under novocain anesthesia, the scalp wound was excised and an occipito-petrosal comminution with indriven fragments was found. When these were removed piecemeal, a penetration of the dura was disclosed over the occipital lobe, with a marginal tear of the lateral sinus which was secured by a silver clip. The sigmoid sinus was also injured by a large, loose fragment which was not dislodged, as efforts to do so led to a sharp venous hemorrhage. One large detached fragment apparently opened into the middle ear. A large amount of disorganized brain with blood clots was removed by suction and irrigation. The dura over the cerebellum was very tense and bluish; the membrane was incised with evacuation of a large blood clot and bloody cerebro-spinal fluid; incision closed. The scalp wound was closed with gutta percha drainage. Seventeen days later the man was evacuated in excellent condition and with some apparent return of vision in the left fields. Three months later a slight contraction of the field remained, and two months after this he was at work and well save for some headaches and persisting deafness of the right ear.

Velter (*Archiv. d'Ophtal.*, xxxv, 3) made a clinical study of 5 cases of hemianopia: The first had a penetrating injury of the left occipital region, with right homonymous hemianopia and preservation of macular vision; the second received an injury to the right occiput, and a bilateral homonymous hemianopia resulted with macular vision alone remaining for some time. Later the right side of the field recovered until a left inferior quadrantic hemianopia finally became the residual defect. In the third case an injury to the right occiput was followed by a double bilateral hemianopia which changed into inferior hemianopia within a few days and later became a permanent right inferior quadrantic hemiachromatopsia. This is explained as the effect of a large intrahemispheric hematoma pressing upon both areas in the region of the calcarine fissure and producing extensive disturbance of the visual field. The final tissue deficit was a small area over the left superior margin of the calcarine fissure. In another case a right homonymous hemianopia which followed a left occipital injury gradually recovered a perfectly normal field after three months. Villaret and Rives report 6 cases of bilateral homonymous hemianopia in two of which both hemispheres were perforated, with vertigo and the hemianopia as the sole residual disturbances.

Cerise (*Arch. d'Ophtal.*, xxxv, 5) details 2 cases of double hemianopia with conservation of macular vision. Vision of 1/10 and 2/100 was recovered after initial blindness which followed an extensive occipital injury. The field, doubly hemianopic in each eye, was reduced to central vision 10° to 15° about the fixation point. There was convergence insufficiency, hemiparesis and difficulty in writing.

Bourhonet and Ronneaux (*Ann. d'Ocul.*, cliii, 7) recount an interesting case of a soldier who was struck in the right temporal region by a shell. A few weeks later he complained of headaches, loss of hearing and noise in the right ear. Examination of the fields showed a lower left quadrantic hemianopia. A diagnosis of serous meningitis was made, circumscribed in the right temporal fossa and pressing upon the right optic tract between the chiasm and the cuneus. A lesion of the occipital lobe was considered excluded by the lack of optic hallucinations. Trepanation of the right temple permitted the outflow, under pressure, of about 40 cc. of fluid. Recession of the hemianopia followed gradually to the point of the complete disappearance within two months.

Piéron argues for the existence of at least three degrees of cortical hemianopia, basing his argument upon the case of a soldier who was injured in the left occipital region from the explosion of a shell. Though apparently blind half of his visual field proved in reality to possess vision of large shadow masses, or very luminous surfaces belonging to this part of the field. The boundaries of light vision in the anopic field, provided sufficiently intense luminosity was employed, were the same as those of the normal field. There was, however, in this blind half of the field achromatopia and asteriopia, or loss of vision for colors and loss of vision for form and size. Piéron would thus recognize in cases of hemianopia the following three degrees: In the lightest cases, hemiachromatopia; in more marked cases, hemiasteropia; and for the complete cases, especially with radical destruction of the center or of the optic tracts, hemiaphotopia, or complete hemianopia.

Moreau (*Ann. d'Ocul.,* Vol. 155, p. 357, 1918) discussing disturbances of macular vision caused by traumatic occipital lesions, believes that: Since vision consists not only in recognition of the existence of a point or line, but also in determining its movements, distance, depth, etc., these factors should be investigated in hemianopsia as well as the determination of the losses in the field. That is, in the ordinary visual fields there are zones of orientation, distinction, and precision, in passing from the periphery to the center. By the use of a stereoscope with Haitz' or Joseph's charts these zones can be determined. Different letters of the same size are used, instead of points or squares, and the places where these are recognized are joined into a zone of "distinction." The examination must be frequently interrupted to avoid the antagonism of the visual field. The central vision is tested by means of Holmes' or Pigeon's stereoscope provided with special test objects, consisting of 6-rayed stars, either white on black background, or black on a white background. If the largest is seen complete, the area of central vision is normal. If branches or part of the nucleus is obscured, smaller ones are tried until one is found which is seen complete. Three case reports with interesting representations of the visual fields are given.

General results of visual troubles in hemianopsia with central lesion. (a) Reading.—There is an irregular rhythm of reading by hemianopes different from the uncertainty of the amblyope. It is more difficult for them to read writing than printing, and unfamiliar than familiar texts. (b) Writing.—On unruled paper, the right hemianope has much more trouble than the left. On ruled the difference is not so great. In the former, the lines slant downward.

Much interest has been evoked by the attempts to estimate the evaluation of the invalidity produced by the various hemianopic defects. It is obvious that the extent and position of the scotomata, and particularly the matter of macular involvement, are all of the highest importance. On account of the marked change in the extent and form of the defect which often occurs during the months just following the injury no immediate estimate of the degree of loss should be made. Coutela is quoted as recommending a maximum of five years for a final decision. It must, moreover, not be forgotten that all these injured soldiers show general cerebral symptoms, and that it is necessary to bear in mind the concomitant nervous disturbances.

Marie and Chatelin have found that 10 per cent. of soldiers with cranial injuries have some involvement of the cortical visual centers, with hemianopia as the principal symptom.

Morax, Moreau and Genet (*Arch. d'Ophtal.*, xxx, 4) undertake to establish the amount of compensation due to soldiers with such disturbances and give to each nasal half of a field the value of 12 per cent., the temporal half 24 per cent. and the two halves 36 per cent. Homonymous hemianopia impairs the vision much more than the loss of one eye. For quadrantic hemianopia the value of each nasal quadrant is figured at 6 per cent, with 12 per cent. for each temporal quadrant. For a bitemporal hemianopia 64 per cent. is given as the commensurate value and 32 per cent. for binasal, while hemianopia in an individual who has sustained enucleation of the other eye is placed by 36 per cent. for the hemianopia and 33 per cent. for the loss of the eye.

5. *Quadrantic hemianopia.* Quadrantic or incomplete hemianopia is most often the result of injury to the optic radiations, the lower fields being nearly always involved and the actual direct and residual injury being limited to the superior lip of the calcarine fissure or to the portion of the optic radiations terminating there. Frequent permanent defects of this nature evolve out of initial total blindness. These defects are homonymous, and while in the main superimposable, often are not identical mathematically. As a rule such sectors of blindness lie between the vertical line through the fixation point and one of the oblique radii. Defects bounded by an adjacent radius are more uncommon. Pincus (*loc. cit.*) details a case in which sector quadrantic defects in the left upper quadrant were caused by a piece of shell lodged in the optic radiations, paralleling Axenfeld's unique case of residual right upper quadrantic hemianopia due to a bullet lodged close beneath the occipital cortex. Marie and Chatelin report 5 cases of inferior quadrantic hemianopia and many other observers have added to the numerical total of reported cases.

Holmes (*Brit. Jour. Ophthal.*, July, 1918, p. 366) describes a characteristic case where a circular contused wound just to the right of the midline and centered 3 cm. above the inion, was the point of entry for a whole shrapnel ball which had lodged about 1.5 cm. to the left of the midline, about 2 cm. anterior to the occipital bone and with its lower border 5 cm. above the inion. The visual fields were first examined five weeks after injury. There was no headache or other cerebral symptom aside from the visual defect of which the patient was scarcely aware. Central vision was 6/9 in each eye, but a complete right inferior quadrantic hemianopia was found extending to 1½° from the fixation point, together with a sector-shaped left inferior paracentral scotoma which lay between the inferior vertical line and the radius at 45° to it; it came to within 4° of the fixation point. The color fields were normal save in the blind areas.

The quadrantic hemianopia in this case was clearly due to the extensive lesion produced by the shrapnel ball in the mesial part of the left occipital pole above the level of the calcarine fissure, the case suggesting that those portions of the retinæ which lie along the superior vertical radii send their afferent impressions to the dorsal portions of the visual areas which lie uncovered on the mesial surfaces of the occipital lobes.

6. Hemianopic scotomata. Hemianopic scotomata are the most common visual defects found after occipital wounds but are essentially associated with those of the tangential variety producing moderate and superficial injuries. The outer table is usually intact, and trepanation, which should be the rule, commonly reveals a crack in the inner table, with more or less hemorrhage beneath the dura and varying injury to the brain substance.

Although the visual defect is absolute, these scotomata are nearly always ignored or are unrecognized, unlike the inferior and quadrantic hemianopias, where a vague sense of visual modification exists. Accordingly such defects are easily missed and have to be sought for with the greatest care, using the Bjerrum screen and studying, especially, the region about the fixation point. When sought for by this method and in a routine manner, such defects are found in over 1 per cent. of the projectile wounds of the skull, and are extremely common in all the lighter injuries of the occipital lobes. When the poles of both occipital lobes are injured central vision may be completely lost, while a unilateral wound causes homonymous scotomata in the opposite halves of the fields. Their topography is variable: they may be central, paracentral or peripheral; some are simple, others multiple and homolateral or heterolateral. Hemianopic scotomata are characteristic in being practically always homonymous, comparable, if not mathematically identical in form and unmodified by time, facts which, in common with the accompanying occipital wounds, identify them as the product of lesions of the central optic pathways rather than of the optic nerves or the retinæ. At times, as suggested by a case of Mariet's, the repeated, careful plotting of these scotomata may give an early and valuable index of abscess formation.

The most interesting and important of these scotomata are the central and the paracentral, and in illustrating their types and in the discussion of their illumination of the uncertain details of cortical visual localization, the admirable work and conclusions of Holmes are followed.

Homonymous paracentral scotomas are frequently produced by injuries of the polar region of one occipital lobe. The visual fields in the following case represents a characteristic type:

A soldier was wounded by a fragment of shell and was operated on in a casualty clearing station the same day. He was unconscious or at least remembers nothing that happened during the first few days. Then he discovered that he could not see accurately to his left, but frequently noticed flashes of light to this side which he compared to ordinary gun-flashes. He had also a feeling "that there was always something standing on the left side, a person or something" but he could distinguish no form. His vision improved quickly, but became stationary within a few weeks.

The wound was represented by a healed vertical scar in the occipital region immediately to the right of the middle line. Beneath it there was a defect in the skull, 4¼ cm. in vertical length and 2 cm. broad, which extended from 1 cm. above the inion upwards, parallel to the mesial sagittal plane of the head.

Five months after injury the vision was 6/6 in each eye. He complained that in reading he had difficulty in finding the beginning of a line or paragraph, and even the first letters of a long word. In the street he often failed to see people in front of him and to his left. The peripheral limits of his vision to a circular white object 7 mm. in diameter were normal, but there was a large left paracentral scotoma which extended from the fixation point to about 20 degrees to the left. Its edges were markedly sharp and definite.

In this case an injury of the right occipital pole, which must have involved the posterior end of the area striata, caused a left homonymous paracentral scotoma. This is the condition of the visual fields most commonly associated with lesions of this region. The scotoma generally extends up to the fixation point, and usually its size can be seen to bear a close relation to the depth of the wound. "Such cases supplement the evidence we have already obtained that the center for macular and paramacular vision lies near the posterior ends of the hemispheres."

In another case, with a similar defect in the left sides of the visual fields, total destruction of the posterior part of the right striate area was found on post mortem examination, when death took place five weeks after the infliction of the wound.

Smaller paracentral scotomata are frequently limited to either the upper or lower homonymous quadrants. Their position in the field of visions always bears a close relation to the site of the wound in that they lie below the fixation point when the injury involves the upper and posterior end of the calcarine area, and above it when the ventral portion of the visual region is damaged.

The following case is a typical example of an inferior paracentral scotoma.

Lieut. H. was wounded in Nov., 1915, by a bullet. He found at once that he could not see the ground at his feet properly. When he was examined four days later his only complaint was that in trying to read he could not see the lines immediately below that on which his eyes were directed, though the rest of the page was visible to him. There was a tangential scalp wound with its entry 2½ cm. above and 4 cm. to the right of the inion, while the exit was in the middle line 2 cm. above the inion.

Peripheral vision was undisturbed, but there was a small absolute paracentral scotoma in the left lower quadrants which extended from the fixation points outward and downward to about 9 degrees. This patient was examined again recently, more than three and a half years after the infliction of the wound. Peripheral vision for both white and colors was unrestricted, and his visual acuity was 6/6 in both eyes, but the paracentral scotoma remained practically unaltered, the only change being that he could now recognize a moving white object between six and nine degrees from the fixation point, where he was at first totally blind. But in this narrow zone vision for white was still very defective, and colors could not be recognized.

The only inconvenience he experiences is in his work as an accountant; in ''running up'' a column of figures he adds them correctly, but in ''running down'' a column he often fails to see the left-sided figures, that is the hundred and the thousand units.

In the case described by Abelsdorff, a wound of the occiput was followed by a small left paracentral hemianopic scotoma which, during the healing of the wound, was transformed into a bilateral central scotoma, without the presence of any other anomaly of visual acuity.

Superior paracentral scotomata are much less common, Lister and Holmes having described two cases, Marie and Chatelin two, Riddoch one and Holmes three additional up to August, 1918. In all these patients the lesion, as far as could be determined, involved the lower part of the area striata indicating, therefore, that the retina immediately below the macula is represented in the lower portion of the calcarine area.

This form of injury is illustrated by the case of an officer who was wounded by a fragment of shell-casing. He was not made unconscious and, after the first few days, complained of no symptoms nor of any visual disturbance. About three weeks later increasing headache developed, accompanied by a slight degree of optic neuritis. The wound was an oblique gutter 3.8 cm. long, extending from the upper margin of the inion to the right and slightly upwards. A radiogram showed a depressed fracture, which at operation was found to overly an extensive extradural clot. The dura was bruised but not lacerated and, accordingly, was not incised. Recovery was uneventful. Four weeks after the injury, he was unaware of any visual disturbance and the peripheral limits of both white and color fields were normal in each eye, but a small absolute paracentral scotoma, which extended from the fixation point to about 4° was found in both upper left quadrants. The absolute scotoma reached slightly below the horizontal line where it was continuous with an area in which vision for white objects—7 mm. disc—was very imperfect and color vision was lost.

Another instance of a superior paracentral scotoma was afforded by a soldier who was wounded by a fragment of shell which burst behind him while he was riding. He was dazed for a while but did not lose consciousness and was able to ride alone to the first-aid post though his sight was considerably affected. He was immediately transferred to a casualty clearing station, where part of the missile that was imbedded in his skull, and splinters of bone which had been driven through the dura into the right occipital lobe, were removed.

The wound, five months later when he was examined, was represented by a scar slightly above and to the right of the inion, with roughened bone and a defect in the skull beneath it. Radiographic plates revealed a small circular trephine hole, 2 cm. in diameter, its center being 1½ cm. above the inion.

He stated that his vision, which was at first seriously impaired, improved quickly and that it was as good when he reached England, a fortnight after being wounded, as it was at this examination. He complained only that he had difficulty in reading, as he generally missed the first few letters in long words.

Central vision was 6/6 in each eye, and on examination with a perimeter the peripheral limits of the fields were found to be normal. He had, however, a small absolute scotoma to both white and colors to the left of the fixation point. It was carefully mapped out by the aid of a screen; the greater part of it lay in the left upper quadrants, into which it extended 5-6 degrees from the fixation point, but a small part projected into the lower quadrants. Its edges were remarkably sharp, and were identical to white and colors, an object moved from it into the seeing portions of his fields appeared suddenly as if it had come from behind a screen. The blindness extended directly up to the fixation point.

Here, as the wound was immediately above the inion and the scotomas lay chiefly in the upper quadrants, the causative lesion must have affected the lower and posterior part of the striate area.

Velter (*loc. cit.*) reports an instance of tangential trauma in the midline of the occiput which was followed by a rapid recovery of the initial blindness to the point of a normal field for white but a contracted color field. A small absolute scotoma was found in the upper right quadrant, of the paracentral type.

Bilateral paracentral scotomata are less common, but when they occur they furnish further confirmatory evidence of the conclusions to which we have already come. The following is a good illustrative case: Pte. B. was wounded by a machine-gun bullet which passed through his steel helmet. He was dazed or semi-conscious for a short time. He then walked alone to the dressing station, but fell repeatedly into shell holes and across obstacles as he could not see the ground before his feet. An operation was performed on the third day after the infliction of the wound, and a fortnight later he was transferred to England where he remained in hospital for four months. During this time he stated that he could see quite well, and was not aware that his vision was affected. He volunteered for active service and went to France again 2 years after the injury, at which time the wound was indicated by a transverse horizontal scar, 8 cm. in length, which was bisected by the middle line and crossed it 4 cm. above the inion. Radiographic plates revealed two small circular openings in the skull, one on each side of the median line; their lower margins were 2½ cm. above the point of the inion.

Central vision was 6/18 in each eye and the peripheral limits of his visual fields for both white and colors were normal. There was, however, a large absolute bilateral inferior paracentral scotoma, more extensive in the right than in the left quadrants, which on the right came to one degree from the fixation point, and 2½ degrees from it on the left. This area of total blindness was surrounded by a zone in which a moving object could be seen, though it appeared gray and indistinct, and in which the colors of test objects could not be recognized. Except in this amblyopic area the color fields were normal. In this man both hemispheres were obviously injured above the level of the calcarine fissures, and the resulting blindness was limited to the inferior quadrants. The fact that the blindness did not extend into the immediate area of the fixation point is probably to be attributed to the escape of the posterior extremities of the visual cortex.

Not infrequently two or more scotomata coexist, which may be separated from one another or united into a complex figure. It is on these cases that we can most easily test our hypotheses of cortical projection and if by them we can explain the occurrence of the blind areas as a result of the anatomical sites of the wounds we have a strong argument that they are correct. The following case is an instance of a right inferior paracentral scotoma while to the left of the fixation point there was a similar area of blindness, chiefly above the horizontal plane. This observation was made on a man six weeks after he received an oblique gutter wound which crossed the middle line of his skull 2 cm. above the inion; it passed from below upwards and to the left, and consequently injured the lower portion of the area striata on the right side, producing the left superior scotoma, and the upper part of the visual cortex on the left hemisphere, causing the defect in the right inferior quadrants.

This series of cases illustrates the evidence that Holmes' observations furnish on the cortical localization of central and pericentral vision. It proves that the macular and perimacular regions of the retina are represented at or near to the occipital poles of the hemispheres. It is probable that the portion of the area striata which frequently spreads over the occipital pole and on to the lateral surface of the brain may be the center of macular sight. The frequency of paracentral scotomata is consequently accounted for by the more exposed position of this part of the visual area than of that which lies on the mesial surfaces of the hemispheres. It seems very probable too, that the maculæ have anatomically larger representations in the cortex than the less highly specialized peripheral zones of the retina, and in this we may find the explanation of the frequency of small areas of blindness in the neighborhood of the fixation point, though the causal lesions may be relatively gross.

According to Rönne (*Klin. M. f. Augh.*, Vol. 56, p. 501) the incongruence noted not infrequently in the deficit areas in the visual fields seen after occipital injuries may be due to errors of observation in perimetry which may be avoided by using a series of test objects. He further concludes that true incongruence exists when the lesion is at a part of the optic path where the fibers from corresponding retinal points are not yet associated, a condition more likely to exist the more anterior the injury, as the pronounced hemianopic incongruence which indicates a lesion of the tract near its junction with the chiasm. Owing to the normally greater extent of the temporal field its outer part is not associated with any part of the nasal field of the other eye, but remains unpaired, and incongruence may, therefore, exist to the extent of this unpaired portion of the temporal field or, at least, in so far as the temporal defect in one field may exceed the nasal defect in the other. Incongruence may occur in respect of an upward divergence of the vertical margins of hemiopic fields. This symptom is not concerned with the arrangement of the nerve fibres, but with the fact that the hemianopic symmetric plane does not fall exactly in line with the sagittal plane of the eyes. According to Wilbrand, the cortical representation of corresponding points may be irregularly arranged, and thus incongruence in the fields may be produced. The sparing of the macula or overflowing field of Wilbrand is another form of incongruence. Rönne concludes that this is due to a purely peripheral interweaving of the nerve-fibres in the retina. At the same time a difference in the two sides in this respect must in all probability be referred to an irregularity in the arrangement of the cortical representation, as individual irregularities in the arrangement of the nerve-fiber bundles may exist despite the fact that in the great majority of cases the mixing of the fibers is extremely regular.

Myerhof (*Klin. M. f. Augh.*, Vol. 56, p. 62) also believes that incongruent hemianopia is due to an unusual arrangement of the nerve fasciculi in the occipital lobe. He reports two cases of this type produced by occipital injuries.

Localization of peripheral vision. If all our experience points to a posterior representation of macular vision in the calcarine regions we may by exclusion assume that the center for peripheral vision lies in the anterior part of the visual areas. There is, however, relatively little direct evidence of this. It is true that this region of the brain is not uncommonly injured by gunshot wounds, but as the anterior part of the calcarine area is surrounded on each side by the optic radiations that carry all visual impressions corticalwards, the visual defect produced by such a cortical lesion would be complicated by the presence of blindness due to interruption of the fibers of the radiations. Riddoch has, however, observed a case in which peripheral contraction of both halves of the visual fields was associated with the presence of a missile and fragments of bone between the mesial surfaces of the occipital lobes, in such a position that the anterior parts of the areæ striatæ were probably injured. Holmes has also recorded a case with loss of peripheral vision in the homonymous fields in which a missile was located at the juncture of the calcarine and parieto-occipital sulci. The following case is further evidence in this question: Corporal W. was wounded by a fragment of shell which dazed him for a moment, but caused no noticeable affection of his sight. He was operated upon in a casualty clearing station the next morning. His wound healed quickly and he remained free from symptoms except headache for four months. When one morning his right side became suddenly numb and weak, and a dull black spot appeared in the vision, he referred it to the lower margin of the outer canthus of the right eye, and repeatedly tried to rub it away, without success. After some minutes he began to see flashes of light "like lightning, uncolored," which flashed from the black spot toward the center of the eye; these persisted for ten or fifteen minutes. Then he lost consciousness and was probably convulsed. This was the only severe fit he had, but two minor attacks have occurred on an average every day since then. These always commenced with the appearance of one or two black spots which he referred to the lower margin of the right outer canthus. They were at first very faint, but became more and more distinct, and then flashes of light began to shoot from them toward the center of his right eye, persisting as long as thirty minutes, and appearing whether his eyes were closed or open. In these attacks he felt strange, as if he were going out of his mind, and after them he had considerable headache.

When examined, seven months after the infliction of the wound this was "represented by a small circular trephine opening immediately to the left of the middle line of the skull, with its center slightly above the lambda or about 8 cm. above the inion. Radiograms revealed an irregular piece of metal in the brain; in antero-posterior views it was seen slightly to the left of the middle line, and when measured on lateral stereoscopic plates it was localized in the antero-inferior part of the left cuneus, immediately posterior to the junction of the calcarine and parieto-occipital sulci.

His visual fields were repeatedly examined. He perceived a circular white object ten mm. in diameter to the natural limits of his fields, but in the periphery of the lower right quadrants, it was blurred, indistinct, and grayish, and often disappeared from vision for a moment, especially when it was not moved. It also seemed much smaller in this region which extended to about forty-five degrees from the fixation point. He could, however, distinguish the relative size of two objects presented to him in this area as accurately as in homologous parts of his left fields, and recognize the shape of test objects, though the recognition was less certain. When an object 2 mm. in diameter was employed, this amblyopic area was more extensive, especially near the vertical meridians. The fields for red and green objects 10 mm. in diameter, were approximately normal and equal in the right and left temporal fields, but when a large red object 30 mm. in diameter was used he failed to distinguish its color, or saw it only as indefinite grayish-red, in the amblyopic area, though its color was distinct out to 70 degrees in the lower left quadrants.

The radiographic localization of the missile in this case, shows that it was in or near the anterior part of the area striata of the left hemisphere, and the occurrence of amblyopia in the periphery of the lower right quadrants suggests that this is the part of the visual cortex that is concerned with peripheral vision below the horizontal. Further, it was here that the visual spectra, which were undoubtedly due to discharges from the neighborhood of the irritant lesion, always first appeared.

The missile was removed. It was found on the left surface of the falx and probably lay in the anterior and inferior part of the cuneus. Since the operation he has had only one visual attack, which occurred on the second day of convalescence.

Further, all our facts go to prove that the centre for macular or central vision lies posteriorly in the visual cortex, while that for peripheral vision is situated anteriorly in it. The representation of the intermediate zones of the visual fields from the fixation point outward are probably arranged in this order from behind forwards in the visual cortex.

These observations, merely selections from a large number of cases, indicate that there is a definite and real representation of the retinæ in the visual cortex. There can be little doubt, too, of the general principles of this localization: the macular regions are represented posteriorly and the periphery of the retinæ more anteriorly in the occipital lobes, while the upper and lower portions of the retinæ are projected on to the corresponding portions of the visual cortex. Further, the mesial horizontal segments of the retinæ are probably projected in the neighborhood of the floors of the calcarine fissures.

And not only is each segment of the retinæ represented in a definite portion of the visual cortex, but this representation is fixed and immutable, so that if a part of the visual cortex be totally destroyed there will be a permanent blindness of the corresponding segment of the visual fields. Only so can we explain the persistence of such a small scotoma as in the case, which, when examined three and a half years after the infliction of the wound, was found almost identical in size and position to that observed within the first few days of the injury. In other reported cases the blind area has remained unaltered for many months after the injury. There is no place here for the theory of vicarious substitution of the function of parts destroyed, by other regions of the brain.

It is true that the functional loss observed immediately or shortly after the infliction of the wound is generally considerably greater than the permanent blindness, but this can be expected, since, in addition to destruction of a portion of the brain, gun-shot injuries produce less severe damage with temporary loss of function in a zone around it.

It is the rule, in so far as the visual cortex is concerned, that this temporary blindness or amblyopia disappears within a few weeks, and leaves only the permanent defect, provided there is no sepsis, inflammation, or hernia formation. For this reason, observations made within a few weeks of the infliction of the wound, can be utilized in the problem of visual localization. That sight may later return in portions of an area that was at first blind is no valid argument against the employment of such cases in the problem of cortical localization of vision, for any scheme of localization that is true must explain the form and distribution of these temporary changes as well as the permanent loss of function.

Fleischer (Heidelberg Ophthal. Congress, 1916) supports the clinical observations and conclusion reached by Wilbrand that the nerve fibers which supply the temporal crescent in the visual field pass in a bundle separate from the rest of the optic nerve fibers, separately from the chiasm to the occiput. Fleischer believes that his observations made in shot wounds of the occiput show that these fibers run separately in the occipital lobes as well, where they have their own area of distribution. In one case which he describes, the temporal crescent of one eye was destroyed by a shot lying just beneath the cortex of the lobe, whence it was later removed. In two other cases the crescent was partially preserved, in one case after the extraction of a bullet from the occipital lobe, in the other after the formation of an abscess following a shot wound.

The marked lateral situation of the shot in the first case, with the position of the wound close to the middle line in the last, make it seem probable that the cortical area of the temporal crescent lies somewhat laterally in the visual area of the occipital lobe.

Villaret and Beaulieu (*Ann. de Méd.*, March, 1919, 5, No. 6) in their interesting discussion of some rare varieties of permanent alteration of the visual fields after occipital shots, instance among cases of horizontal hemianopia, vertical hemianopia with hemianopic encroachment upon the fields usually uninvolved and central and paracentral scotomata, three cases of annular scotoma. In the first case, trephined the day of the injury, there was depressed fracture of occiput 3x2½ cm. in the left inferior occipital region with occipital contusion and some pulping. No foreign body was shown by X-ray.

A closed annular scotoma was disclosed having irregular zigzag borders and larger on the left than on the right. The fundi were negative. The second case exhibited a complete annular scotoma in the left eye and in the right eye an incomplete paracentral scotoma occupying the equatorial and paraequatorial portions of the two right quadrants with a small scotoma above. This incomplete ring corresponded in situation to the complete annular scotoma of the left. The injury was a depressed fracture of the skull in the parieto-occipital region, 7 cm. above the external occipital protuberance and 7 cm. above and posterior to the mastoid. The third case presented an incomplete bilateral annular scotoma, embracing about 3/4 of a circle in the lower half and the left upper quadrant and of variable width. When superimposed the scotomata were not identical, but were approximate. The fundi were negative. The lesion was a depressed fracture 3x2 cm. in the right occipital region placed 2½ cm. from the median line and 3½ cm. above the plane of the external occipital protuberance. The radiograph showed two small bone splinters lodged in the brain beneath the wound. In the first and third cases the hemianopic annular scotomata must be explained either by a bilateral symmetrical lesion of the optic radiations, which seems impossible here, or by the destruction of commissural fibers in the corpus callosum which connect identical parts of the visual centers. The second case showed fundus changes and pigmentation and is, therefore, not free from the possibility of injury or disease of the optic nerve involving the concentric arches of the optic nerve fibers in the retina. Lister's case of ring scotoma due to the lodgment of a foreign body on the optic papilla is reminiscent in this connection.

Loss of color vision. Some of the hemianopic areas show an incomplete loss or a diminution of sight, and in others a zone of diminished vision may surround a patch of complete blindness. Areas of amblyopia are very common and in such areas the state of vision varies considerably. If the disturbance is severe only large white objects when moving can be recognized, but they appear "dim and misty," or "dirty and grey" instead if white, and the patient has no clear idea of their outline or size. When they cease to move he sees them no longer and they disappear. Smaller white objects may not be visible within this area or in some part of it; in fact the blind area generally varies indirectly in extent with the size and brightness of the object by which it is mapped out. In such areas color cannot be perceived.

When the affection is less intense white objects of moderate size can be seen even when at rest, though they appear indistinct and greyish, but small test objects may disappear momentarily from vision. The patient frequently states, too, that the objects presented to him seem smaller than they do in normal parts of his fields. This is not a specific loss of the appreciation of visible size, since the patient has always an idea of the magnitude of the object, if he can see it, and Holmes has always found that these patients can distinguish the relative sizes of two test objects presented in succession almost as accurately as in homologous normal parts. The dimness and indistinctness of the visual image causes them to judge the object to be smaller than it is; he misinterprets the defective perception as smallness. In these cases color perception is generally lost, or only relatively large areas of red and green can be recognized; but then their tints are usually pale and indefinite.

Finally, in the mildest degrees of amblyopia even small white objects can be perceived, whether in motion or at rest, though they usually seem dim; and red and green do not appear in their natural tones; a deep-red is often "yellowish-red," and green "pale or greyish."

Holmes saw no case in which color vision was lost in portions of the field in which the perception of white was unaffected, and knows of no conclusive evidence that a purely isolated loss of color vision ever results from lesions of the mesial surfaces of the hemispheres in the region of the visual sensory cortex.

Effect of blind areas in daily life. Ordinary clinical experience teaches that a man with homonymous hemianopia is frequently unaware that he has lost one-half his seeing field, and that he learns to appreciate it only by experience. And the same is true, as a rule, in respect to blindness produced by traumatic cortical lesions. A man with complete hemianopia rarely complains spontaneously, when he is first examined, that he cannot see to the one side, and usually there is no subjective blackness or mistiness to this side unless central vision be affected; this part of visual space simply does not exist for him. This holds true as well for small patches of blindness to one side of the fixation point. A man with a left paracentral scotoma which extended to the fixation point constantly jolted into people who passed on his left side in the street; his consciousness seemed to be so little aware of his blindness that he rarely took precautions to avoid accidents which might occur through it. Even more striking is the effect of a small paracentral scotoma limited to either the upper or to the lower quadrant. One case, for instance, saw only the feet or legs of a person approaching on his left side and connected this part with the idea of a whole man only by a deliberate act of attention. Similarly, in reading, he missed small words and letters, while another case failed to include the left side of the figures in the column he was adding, even after long experience he continued to miss them. These patients fail to realize their own blindness; the space not seeing is simply space that does not exist for them, and they are no more conscious of its absence than is the normal person of his own blind spot. When, however, central vision is affected, so that the object on which the eyes are directed cannot be seen distinctly, the patients generally complain of a mistiness of vision or of a blackness in front of their eyes when the blindness is here complete, though on careful questioning it is generally found that this is not a positive sensation of blackness but a state of not-seeing.

Positive visual phenomena. Positive subjective visual phenomena are not uncommon during the first few weeks after the infliction of a wound. The most common form is the appearance of flashing lights or stars, which may be either white or colored, in a part of the blind or amblyopic area. It is rarer that these subjective phenomena occur at a later period. The local epileptiform seizures with which one man suffered always began with the appearance of lights of all colors on the margin of an area of peripheral blindness, which grew brighter and brighter until they became intolerable as he lost consciousness; he exteriorized these centrally-produced sensations so vividly that on one occasion he assaulted an orderly who stood beside him "for flashing those awful lights into my eyes." In another case brilliantly colored stars appeared on the margin of a paracentral scotoma. Incidentally the occurrence of colors in these sensations produced by discharging lesions in the calcarine region is an argument that color perception depends on this portion of the brain.

In a second type of these visual sensations of central origin, more complex figures appear in the blind area. These, which are more or less constant, and do not move, are always extremely indefinite; a few men complain that there always seemed to be "a man or something" standing on their blind side, and one man with inferior horizontal hemianopia stated that when he tried to read there seemed to be a white hen on the lower part of the left page of the book. But when questioned, these patients admitted that they could never recognize a shape, there was only a "feeling that there was something there," something too ill-defined to describe. These indefinite forms appear only in the early stages and generally in blind areas that are recovering. They are probably due to the misinterpretation of feeble and indefinite sensations excited in functionally depressed areas of the visual cortex.

V. *Disturbances of Visual Association.*

Holmes saw during the war (*Brit. Jour. Ophthal.*, 1918, Vol. ii, p. 449) eight cases of men with gunshot injuries of the brain who had disturbances of visual space perception. All presented more or less similar symptoms and, as most of them remained under observation for considerable periods, their condition was investigated in detail repeatedly. Their disturbance could not be ascribed to blindness or amblyopia, for central vision was good in all and though there were defects in the fields of vision in several, these defects bore no relation to the symptoms which were identical in other men in whom the fields were normal. The symptoms were not connected with paralysis or loss of sensation and there was no serious degree of mental deterioration in any of them. One man only had aphasia of severe degree. Holmes (*Brit. Med. Jour.*, Aug. 23, 1919, p. 230) summarizes those disturbances and his conclusions arising from their study as follows:

The most obvious symptom was the inability of the patients to determine the position in space in relation to themselves, of objects which they saw distinctly. On holding an object before a man he named it correctly and though his eyes fixed the object accurately he stretched out his arm in a totally wrong direction when asked to grasp the object. Another struck the observer's face when asked to point to a pencil held two or three feet from his side. Similarly when asked to pick up from a table objects which they could see and recognize, these men could never bring their hands directly to the objects, and often made very gross errors in direction. One intelligent man described his experience in eating from a bedtable. When he tried to take a piece of bread he found his hand under the table rather than above it, and on attempting to seize a cup of tea he found his fingers first in the tea and next on a plate to one side of the cup.

This inability to recognize the positions of objects seen was obvious whether they were in central or peripheral vision, but in the latter case the errors were much greater; most of the cases were able to localize fairly well though not with normal accuracy.

When sight alone was relied upon, however, they could not localize the positions of an object in space but when it touched any part of their body, localization with the hands was immediate and exact, touch furnishing the necessary local knowledge which they failed to obtain from vision alone. These patients also accurately localized the directions of sound; when blindfolded they pointed in the direction of a noise and walked towards anyone who called them, as readily and as accurately as a normal person.

The estimation of distance was most severely disturbed. They frequently overreached or underreached objects, an example being given in the case of a man who was asked to grasp a paper about six yards distant and who at once extended his hand towards it and continued groping for it as he neared the object and even after his hand had passed it. They were also unable to make even approximate estimates of the distance of objects; a tall chimney about 500 yards away seemed "perhaps twenty yards" to one man who remarked "Everything I see seems to be the same distance from me."

The relative position of two objects which were in vision at the same time could not be determined with any accuracy and especially the relative distances from themselves. The men either guessed indiscriminately that one object was nearer or confessed their inability to decide, but when allowed to touch or to walk to the several objects the solution was accurately made.

Inability to distinguish the absolute and relative lengths and sizes of objects was another prominent symptom of this group of cerebral cripples. They could not estimate at all accurately the length in inches or feet of a rod or line unless they were familiar with the object shown; they were always uncertain which of two pencils was the longer unless the difference was marked, they could not divide a line or find the center of a circle accurately, and one patient who attempted to divide a loaf of bread in equal parts, apportioned for himself a piece fully six times larger than the piece given the observer and failed to note the inequality of the division until he touched the two portions with his fingers.

The inability to localize objects in space by vision alone was very obvious when these patients were allowed to walk about. Some of the men walked repeatedly into walls and occasionally with such violence as to hurt themselves. They had no idea of how near they were to the walls although the walls were clearly perceived. They experienced difficulty in getting around obstacles which they encountered unless they used their hands, when they felt their way around in the same manner that a normal person may do in a dark room.

All these patients had difficulty in learning their way about. One man, even after three months in the same ward, could not go directly to his bed, although he could see and identify it, if he had to make two or three turns while on his way. Another was tested day after day in an open space divided by a partition in which there was a gate, but even after weeks of training he could rarely go straight through the gate to a point beyond it with which he was familiar. The visual impressions out of which they would normally construct their ideas of space were devoid of spatial qualities and this made it impossible for them to obtain clear pictures of the topography of even small areas. The topographical memory of ways and places with which they were acquainted before their injury was also severely involved in spite of good memory pictures of these situations. Though they could describe what they passed on the way and even the general appearance of the streets, they retained no idea of the relations in space of the separate objects or streets to one another.

The inability to recognize the position in regard to self of objects seen and the relative location of several objects, as well as to retain a correct picture of the spatial relations which is normally acquired by sight, produced many other symptoms. Four or five similar coins or matches placed irregularly before them could not be counted. They generally turned their eyes from one to another and back again, counting and recounting till they became hopelessly confused when coins of different sizes and colors were used they could distinguish those which had already been included in the tally and consequently succeeded. The coins were counted without difficulty when handled.

The same disturbances accounted for the difficulty met with in reading. Although they could see the smallest type and recognize the written words they were often unable to read the words of a line in their correct order and their eyes jumped irregularly from line to line, or even to another paragraph or column. The most constant difficulty was to find the beginning of the next line when they had finished reading the words of one. Writing was beset with the same difficulties arising from the same factors. None of these cases, excepting a single aphasic case, had a trace of agraphia but the individual words of the letters they essayed to write were placed so irregularly and the lines crossed so frequently as to render the whole effect scarcely intelligible.

Recognition of movement was accurately investigated in but one of Holmes' cases in which it was found that movement towards or away from him was not detected so long as it remained in the line of the visual axes, while the slightest lateral or vertical movement was recognized and identified at once.

Riddoch (*Brain,* 40:15, Part 1, 1917) in an important paper concerned particularly with disturbances of the appreciation of movement following these occipital injuries, introduces his theme with the remark that vision, in large part, is a highly specialized sensation, subject to the laws common to sensations and dissociable into component parts, vision being the product of a synthesis between movement-vision and object-vision, with a synthetic product evinced in the appreciation of form or stereoscopic vision. Riddoch concludes from a series of cases that in restricted visual fields from occipital injuries where some recovery of vision occurs, light and movement are the first stimuli to be appreciated, movement being the first visual stimulus capable of being recorded on a chart as a field. Movement, then, should be given a place among the stimuli which are recognized as originating visual perceptions. The recovery of vision for movement begins in the peripheral field. Appreciation of movement and recognition of an object are always dissociated in patients in whom recovery of vision can be demonstrated; the field for the former, which is the more primitive perception, being the larger. This dissociation is a valuable aid in prognosis, for when it is absent after a few months have elapsed no recovery of vision occurs.

Riddoch finally considers that the types of visual dissociation exhibited by his cases are analogous to the dissociations of general somatic sense impressions, described by Head and his coworkers as occurring from cerebral injuries.

Disturbance of visual attention was shown by all these patients. Every object in central vision seemed to absorb attention so that images which fell on the retinal periphery were often unobserved; attention was incapable of noting two or more visible objects at the same time, as when the observer's hands were held on either side of the patient's visual axes he could instantly detect the movement of either the right or the left, but failed to see the simultaneous movement of both. If two pencils were on the table at the same time but one could be recognized at a time. This affection of visual attention showed itself also in the lack of interest which these men showed in events which were taking place about them unless their attention was directed by sound or other sense impressions. In walking they frequently passed things which would have aroused the interest of normal persons but which they did not observe. This visual inattention was not due to blindness or to other defects in the visual fields, as no defects which could explain it were discovered after careful examinations, and images were frequently perceived on parts of the retinæ where similar images passed unnoted immediately before or after. There was no regularity in perception. This is a condition which results not infrequently from lesions of the parietal lobes and it may be a unilateral or bilateral phenomenon. It is commonly found apart from disturbances of visual localization from which it is entirely independent. It plays a part in some of the symptoms already discussed, however, in that if the visual impressions of objects do not attract attention, the patient fails to notice landmarks by which he could find his way later and by which he could construct a geographical picture of his surroundings. In counting objects he is also liable to miss some of them owing to the fact that their images fail to excite attention. Head and Holmes have described an analogous disturbance of "tactile attention" when cutaneous sensibility is affected by parietal lesions. Though there may be no actual loss of sensibility or raising of threshold, only a certain proportion of tactile stimuli applied to the skin is then appreciated, and this proportion bears no relation to intensity of the stimulus, provided it remains purely tactile.

Abnormalities of ocular movement existed in all of these cases, although none of the ocular muscles were paralyzed and the pupillary reflexes were preserved. The most prominent fault was difficulty in fixation which arose as the natural consequence of defective spatial localization, although as in a few of Holmes' cases and in others which have been recorded, the subjects were unable to deviate their eyes directly to points on their own bodies. This symptom may be due also to disturbance of the central mechanism of the ocular movements, a disturbance on the effective side which is closely parallel to the perceptual affection on the sensory.

Accommodation was similarly affected; when an object at which they gazed was brought slowly towards their faces their eyes failed to converge, their pupils did not contract and, as accommodation did not occur, the object became blurred or indistinct when nearer than about eight inches. This, also, was mainly due to the spatial perceptual disturbances but, as some of the patients could not accommodate on their own fingers accurately, an affection of the central mechanism which controls accommodation must be assumed as well.

The blinking reflex was also abolished and neither blinking nor withdrawal of the head followed a threatening gesture or the sudden approach of an object. In most of the cases this was probably secondary to the loss of spatial perception but in others the cerebral centers concerned in this reflex were probably involved.

The power of recognizing thickness and depth in solid objects (stereoscopic vision) was severely affected in but one of Holmes' cases. Everything appeared flat and bidimensional to this man who identified familiar objects only by associating their areal shape with previously acquired experiences, just as the normal person interprets pictures and drawings as the objects which they represent. He described a man who stood in front of him as flat, "I can only see the front of him, I do not notice that he is thick; I cannot tell the depth in anything." A box seemed to him a piece of flat cardboard regardless of the angle at which he saw it and when placed in his hands he was surprised to discover that it was a box. A glass tumbler appeared like a bit of flat glass which changed in shape as it was moved about, while a flight of steps took the form of a number of straight lines on the floor. Nothing had thickness or depth; everything seen was flat and stereoscopic vision remained abolished during the three months of observation.

In all the eight cases described by Holmes gunshot wounds involved the posterior and upper parts of both parietal lobes. Post-mortem examinations made in two cases (*Brit. Jour. Ophthal.,* Oct., 1918, p. 513) showed injury of the lateral surfaces in the neighborhood of the angular and supramarginal gyri, while the missiles passed through the mesial surfaces immediately dorsal or posterior to the splenium of the corpus callosum. Craniometric measurements in the remaining cases indicated that the same parts of the brain were damaged in them. As similar symptoms have been observed in cases in which there are vascular lesions limited to the lateral surfaces of the hemispheres in the region of the angular gyri, Holmes concludes that disturbances of visual space perception, i. e., the fatalities of spatial orientation, appreciation of movement, stereoscopic vision and visual memory, can be attributed to destruction of this portion of the parietal association area which links the visual cortex to the rest of the brain. These clinical observations accord with the experimental data yielded Sharpey-Schafer thirty years ago by the removal of the angular gyri in monkeys.

The physiological factors on which spatial localization by sight and tridimensional vision depend are those of direct retinal stimulation, the proprioceptive impressions furnished by the ocular muscles, by the muscles of the neck, to a lesser degree by the muscles of the trunk in general, and by the otic labyrinthine mechanism. The loss of any of these factors may disturb the function of localization. In the cases Holmes describes the afferents from the labyrinths and from the ocular muscles were unimpaired. No accurate record of intimate ocular muscle balance is recorded in these cases nor is any record made of the careful static measurements of postural alignment which would accurately and wholly eliminate either of these as factors in the dissociation, but as these are minor factors as a rule save in cases of obvious postural deformity, the symptoms may be attributed logically to a disturbance of the local sign functions of the retina, or to the failure of the brain to associate and integrate these with other afferent impressions. Many direct observations showed that the retinal local signs were affected.

Several other factors are concerned in the perception of distance. Binocular vision undoubtedly plays a part and the proprioceptive impressions from the intrinsic and extrinsic ocular muscles that are excited by accommodation and convergence contribute to it when the object is near. The estimation of distance is also aided by the apparent size of known objects, by their distinction and light-intensity and by the parallax that is obtained on movement of either our heads or the objects. There is no evidence that any of these separate factors were disturbed in Holmes' cases. The inability to estimate distance must be ascribed to failure to correlate and associate the various afferent impressions on which perception of the third dimensions may be based, and to assimilate them with past experiences and thereby supply to consciousness the data on which a correct intellectual judgment may be made.

Loss of stereoscopic vision might be regarded as a natural consequence of inability to appreciate relative distances since it might be argued that this would make it impossible to discriminate the depths of the different portions of a tridimensional figure. But stereoscopic vision was affected in but one of the eight cases in which the perception of distance was seriously disturbed. The appreciation of relative distance, different in light and shade, the parallax and the sense of perception all undoubtedly play a part but it is to the fusion of the non-corresponding images formed in the two eyes and their integration with these other sensory data into the single concept, that we mainly owe the appreciation of depth in objects seen. There was no gross disturbance of any of these individual factors in Holmes' cases except the appreciation of relative distance, which the intact faculty of stereoscopic vision in the other cases shows to have been insufficient. The affection of the sense of perception may have contributed, but as this faculty is of intellectual origin and acquired by training and experience, we are ultimately forced to regard loss of stereoscopic vision, also, as the result of a failure to combine and associate the different sensations on which the appropriate intellectual judgments can be made rather than the result of the loss of any of the physiological factors on which it depends.

Holmes (*Brit. Jour. Ophthal.*, Sept., 1918, p. 449, and Oct., 1918, p. 506) gives the detailed clinical record of six of the eight cases of disturbances of visual orientation upon which the foregoing conclusions are mainly based. Another case record which also aids these conclusions and throws much light upon the functions and modes of the cerebral cortex and particularly of those processes concerned in the integration and association of sensations is furnished by Holmes and Horrax (*Arch. of Neur. and Psychiatry,* April, 1, 1919). Other recorded cases in which gunshot injuries produced the same or similar symptoms are those of Heard and Holmes (*Brain,* Lond. 34:102, 1912); Inouye (*Die Sehstörungen bei Schussverletzungen der Kortialen Sehsphäre,* Leipzig, 1909) and Riddock (*Brain,* Lond. 40:15, 1917).

For the most common and at times the most distressing sequel of military injuries of the head, "war headache," as well as for the treatment of localized or reflex phenomena from dural irritation similarly produced, two lines of treatment have recently been advanced: After gunshot wounds, fractured base and concussion, Rawlings (*Brit. Med. Jour.,* April, 19, 1919) found that: 1. The more severe headaches are associated with an intact skull or with small defects. With large deficiencies headaches are less frequent. 2. Frontal and temporal injuries are more commonly accompanied by headache than injuries in the parietal, occipital and cerebellar regions. 3. Wounds near the vertex, in relation to the superior longitudinal sinus, are frequently associated with a severe type of headache. 4. The presence of foreign bodies within the skull is commonly accompanied by chronic headache, more especially when the foreign body is situated in relation to the ventricles of the brain.

In the great majority of cases the headache dated from the moment of recovery from unconsciousness, either from the injury itself or from the operation carried out for the injury. The very first thing that the patient remembers is headache, at first very severe. In many cases special note is made of that point, and in some cases lumbar puncture was carried out for its relief. Previous to transference home the pains abate somewhat, and soon after arrival reach a certain standard. It is on this standard that Rawling gages the diminution, chronicity or increase of the pains. The severity of the headache varies greatly, from mild and inconstant attacks through every degree and grade of headache to the most severe and persistent pains. Perhaps the most common type is a "cyclic" headache. In other instances the pains show little variation in degree, persisting both day and night without intermission; the patient is never free from some degree of headache, varying from "dragging," "weight," "tearing" sensations to a constant dull ache. Wherever the injury, these headaches tend to become localized to the frontal region—behind the eyes—perhaps more acute on the side injured. Often, also, reference is made to the temples. Sometimes also there is a maximum "bursting" pain over the summit of the vertex. In addition to the fact that mental or bodily exertion, noises, joltings, concerts and especially movies, all tend to start the headache or add to its severity, there appear to be two special times of headache development—in the early morning on awaking, and in the evening between tea and bedtime. Associated symptoms are slowing of the pulse rate, with but little raising of blood pressure; marked giddiness; frequent elevation of temperature, night after night; insomnia; slow cerebration; tendency to exaggeration of all reflexes; nausea is uncommon; vomiting is rare; fits, generalized, epileptiform and eye symptoms. These headaches are dependent on some general increase of intracranial pressure, and this in turn is due in the great majority of cases to excess cerebrospinal fluid (cerebral edema).

Rest, dietetics, drugs and lumbar puncture failing to give relief, Rawling urges the performance of subtemporal decompression which will almost certainly bring about relief or cure within forty-eight hours of the operation without in any way risking the patient's life and well-being. A brief summary is given of twenty cases of subtemporal decompression carried out for the relief of headache, chronic and severe, the result of gunshot wound or other injury of the head, the headache leading to total incapacitation and rendering the sufferer utterly miserable. In the majority of cases the patient requested operative measures, all other remedies having failed.

Bonnus, Chartier and Rose (*Bull. de l'Acad. de Méd.*, March, 27, 1919) report favorable experiences from Roentgen exposures in treatment of localized or reflex phenomena from irritation of the dura, sequels of wounds of the skull. Also in motor or sensory Jacksonian epilepsy, in the phenomena of reflex epilepsy, and in certain cases of spastic paralysis from superficial injury of the brain. Some months previous they published a favorable report on Roentgenotherapy in treatment of traumatic affections of the spinal cord and peripheral nerves. If adhesions are not too extensive and too stout, the Roentgen exposures facilitate their absorption. They also act beneficially on cicatrices left by small hemorrhagic lesions. These cicatrices in the meninges or brain are the cause of incessant irritation of cells and motor fibers, and any tendency toward a return to normal conditions is a great gain. Of course the exposures are unable to restore destroyed tissues, so the cases must be selected with care.

The effect upon the eyes of lesions of the cervico-dorsal spine. The influence of lesions of the cervico-dorsal spine upon the eyes is twofold, first through direct or indirect damage or irritation of the cervical sympathetic chains and pathways which have to do with sympathetic innervation of the iris and uvea in general and, second, indirectly, through the postural defect, usually produced at once or later in severe lacerations by the secondary muscular and ligamentous contractures. These achieve their ocular influence by modifying the proprioceptive relations and actions of the cervical muscles, and of the extraocular muscles, thereby influencing the proprioceptive impressions reaching the labyrinth for co-relation and normal proprioceptive function. Such a condition never reaches the pitch of difficulty of spatial orientation but may cause confusion and dizziness and the train of symptoms associated with ocular muscle imbalance.

Although spine and cord injuries have been relatively less numerous than brain and peripheral nerve injuries, yet remarkable advances in organic neurology have resulted from a study of war injuries of the spinal cord. Among these are the demolition of Bastain's theory that reflex functioning is abolished after transection in the lower cervical or upper dorsal regions; a definition of the automatic bladder and rectal functions of the cord; of the automatic cord reflexivity as shown by defense reactions; the syndromes of cord injuries at various levels; the production of organic injuries and alterations in the cerebro-spinal fluid by direct and indirect concussion; destructive changes in distal parts of the cord by direct projectile injury; a better knowledge of the course of sensory fibers in the cord and a clearer understanding of the cause and nature of trophic lesions occurring in spinal injuries.

The ophthalmologist is seldom concerned in the gross spinal lesions for although the cervical sympathetic is frequently involved, the picture is generally so essentially surgical and neurological that the ocular disturbance is relatively inconsequential and goes unrecognized.

Lesions of the cervical sympathetic ganglia and pathways are the not uncommon results of projectile injuries of the lower cervical and upper dorsal regions, where crushing by a fractured transverse process or strangulation in an intervertebral foramen from edema or pachymeningeal hemorrhage may be the cause of the disturbance as often as is the direct injury by the projectile. The eye is always concerned to some extent in the vasomotor, secretory and trophic disturbances which result, although the syndrome described by Claude Bernard in 1858 and first observed clinically by Horner in 1861, is usually incomplete, and most often is transitory. In the production of injuries which involve the sympathetic fibers several factors enter which are peculiar to injuries of the spine such as the facts that spinal traumas are practically always root and cord traumas; that recoil is so marked a characteristic of spinal injuries that the bony lesions are a poor index of the condition of the subjacent nervous structures or of the root and cord injury; that, considering the integrity of the cord remote from the injury, patches of necrosis may occur as far as four or five segments from the site of injury, that considering the integrity of the spinal roots as well as the final postural defects the wide distribution of fractures throughout several vertebræ and the frequent presence of remote cracks and fissures due to tearing away of bony processes by violent ligamentous action, must be remembered.

Holmes (*Brit. Med. Jour.*, 2:769, 815, 855, 1915) describes the pathology of direct spinal concussion, as apart from the indirect concussion of aërial origin which has given no reported ocular reflections. When the cord is not damaged by the fracture or the dislocation of a vertebra, a more or less uniform swelling may be present opposite the site of impact. Microscopically the vessels are engorged and punctiform hemorrhages appear in the gray matter especially. The most striking change is edematous swelling of the most affected segments with either diffuse or focal necrosis and softening. Focal softening also occur in the gray matter but are unrelated to the hemorrhages. The distant lesions in cases of concussion are similar to those found in direct and contusion injuries, for scattered hemorrhages, irregular foci of necrosis, softening and cavity formation and extensive parenchymatous changes often extend over four or five segments in either direction. These consist in the swelling of fibers, either isolated or in groups, the disappearance of which leaves vacuoles and holes in the white matter, giving it a sieve-like appearance. The essential changes are primary disturbances in the vitality of tissue associated with edema and small scattered hemorrhages. Secondary changes may occur due to secondary progressive softening or the development of cylindrical cavities principally in the dorsal columns, as is seen in the distal lesions of direct injuries. It seems probable that these changes originate from the accumulation under pressure of the transuded fluid and degeneration products from a small primary lesion which tracts upward or downward. Waves of pressure in the cerebro-spinal fluid may produce physical defects within the cord and possibly disturbance of its lymphatic circulation, or there may be a difference between the vibratory motion of cord and its bony containing walls, with a resulting bruise of the cord. Holmes noted disturbances of the function of the cervical sympathetic in 36 cases of lesions of all spinal segments between the second cervical and second dorsal inclusive, in the majority of which injury to the sympathetic fibers in the neck could be excluded. Miosis was the most common and prominent symptom or, in unilateral lesions, inequality of the pupils, the smaller being on the side of the lesion and usually failing to dilate or dilating less rapidly and less completely on shading the eyes. Instillations of adrenalin were without effect on the paralyzed pupils. A narrowing of one or both palpebral fissures and some enophthalmos was evident in most of the cases and ptosis was frequent, especially with lesions of the lower cervical and the sixth dorsal segments. In some unilateral lesions lessened or thicker lachrymal secretion was observed, a secretory inhibition which seems to parallel the inhibition of the excretion of sweat on the affected side in most of these cases. Both the ocular and secretory disturbances appear to be more prominent and permanent when the spinal sympathetic centers are damaged than when the bulbar efferent fibers are involved, for in the latter case the symptoms usually subside quickly.

Claude and Lhermitte (*Rev. de Med.* Paris, 35:535, 1916) describe six types of concussion injury of the cervical region with any of which the Claude Bernard-Horner syndrome may be associated: (1) severe and persisting quadriplegic form; (2) hemiplegic form; (3) brachial monoplegic form; (4) brachial diplegic form; (5) cerebello-spastic form and (6) defaced forms.

Roussy and Cornil (*Rev. Neurol.* 3-4 March-April, 1918, p. 233) have observed two cases of spinal concussion from dislocation of cervical vertebræ resulting in quadriplegia and the Bernard-Horner symptom complex. In the first case the sympathetic disturbance persisted on the left side, the lesion being a luxation of the atlas on the axis with fracture of the odontoid process, an accident formerly considered fatal by lesion of the medulla. In the second, with a backward dislocation of the 4th cervical vertebra, an exceptional injury, an alternating sympathetic syndrome persisted, affecting sometimes predominantly the right and sometimes the left side.

According to Schaller, in his admirable review and complete bibliography of spinal cord injuries in warfare (*Arch. Neur. and Psychiatry*, Apr. 1, 1919, p. 471) some believe that the cord lesions of concussion, whether they be due to direct spinal impact or to actual lesion at a distance from the spine, are identical in nature and differ only in degree. The essential lesions are insular foyers of necrosis, acute primary degeneration of myelin, modifications in the ependyma and degeneration of posterior roots. The mechanisms invoked in their production are ischemia, laceration of nervous tissue and the hypertension and transmitted shock of the cerebrospinal fluid.

Marie and Benisty (*Soc. de Neurol.*, Paris, 28:1300, 1914-1915) describe two types of clinical syndromes. In the first the projectile traverses the neck from side to side, the wounded soldier falling forward without loss of consciousness. At first there is quadriplegia with involuntary passage of urine and feces, receding after several days or weeks to a hemiplegia and finally to a brachial monoplegia, The paralysis being particularly well marked in the hand and fingers. The state of the sphincters runs a variable course. There may be severe eschars. There is severe pain whose course parallels that of the motor paralysis. Definite signs of cord lesions are found objectively; Brown-Sequard paralysis, frequently the syndrome of Bernard-Horner, exaggeration of reflexes, unilateral or bilateral Babinski, ankle clonus, incoordination and often a syringomyelic dissociation of sensibility opposite to the paralyzed side. Definite signs of cord involvement persist in these cases.

In the second type the lateral wound in the neck is associated with complete loss of consciousness but with lack of sphincter involvement. At first flaccid brachial monoplegia exists, to which is added a later oncoming spastic paresis and incordination of the lower extremity on the same side and of the opposite upper extremity. At this stage sensibility-disturbances of syringomyelic type on the side opposite the lesion and disturbances of deep sensibility on the same side are present. Exaggerated reflexes, clonus, and the sign of Babinski are found in the inferior extremity involved. The cause is probably spinal concussion (commotion).

A residual Brown-Sequard paralysis is reported by Redlich (*Neurol. Centralbl.*, 34:147, 1915) in a soldier made unconscious and immediately quadriplegic by a bullet passing antero-posteriorly through the neck to the right of the vertebra prominens. The symptoms which developed 15 days later were right-sided motor paralysis, complicated by an inferior brachial paralysis with sympathetic cervical paralysis on the same side and crossed sensory paralysis, these symptoms localizing the lesion at D1 and D2.

In the matter of indirect or aërial concussion of the spinal cord, although anatomic evidence is lacking to support the contention that organic alterations occur in cases of aërial concussion, many clinical cases argue in its favor. Sollier and Chartier (*Paris Méd.*, 5:406, 1915) state that in the zone of violent atmospheric vibration immediately around an exploding shell, the individual suffers a blow compared to that from a solid object and death usually results. In the second zone there is strong atmospheric compression and in this zone hemorrhage of the cord and its envelopes most frequently occurs, while in the third zone of decreasing vibrations the resultant states are comparable to those caused from shock by lightning and electricity. Roussy, in an experience of 81 purely neurologic cases following explosions, believes that the symptoms, save in rare cases, are of a functional nature, as the majority were cured by pyschotherapy, and only rarely were those actually wounded by explosive shells likewise affected. Blood has been found in the cerebrospinal fluid in such cases, however, and cases have been reported by Babinski (*Rev. Neurol.*, 28:581, 1914-1915) of undoubted hematomyelia from aërial concussion; by Marie and Cathelin (*Rev. Neurol.*, 28:777, 1914-1915) of flaccid paralysis of an extremity; by Heitz (*Paris Méd.*, 78, 1915) who in 5 cases of paraplegia with radicular type of anesthesias, sphincter involvement and absence of hysterical manifestations, concluded that the symptoms were organic; Ravant (*Presse Méd.*, 23:114, 1915, and *Bull. de l'Acad. de Méd.*, Paris, 73:717, 1915) reported finding blood or an increase in albumin in the cerebro-spinal fluid in paraplegia following shell explosions without external wounds. No certain case of ocular sympathetic involvement from this particular source has been reported, although a case reported by von Szily as a left-sized lesion of the sympathetic following concussion by a mine explosion may possibly be so considered.

Early operative interference seems by some to be contraindicated as the prognosis depends more often upon the complications than on the actual spinal lesion. Meningo-myelitis is rare as the lesions are rapidly shut off above and below by adhesions. Further, spontaneous recoveries or marked improvement have followed what seem to be grave concussion paralyses. Guillan and Barre (*Presse Méd.*, Paris, 24:497, 1916) report a mortality of 80 per cent. in 100 cases of spinal cord injuries which in their experience were most often due to shell fire. Most patients did not survive 3 weeks, death being due to purulent meningitis, progressive cachexia or disturbance of the sympathetic nervous system of the digestive tract, abdominal viscera or vascular glands mainly. Pulmonary complications and ascending pyelitis are further associated.

Gray (H. M. W.), discussing the early treatment of gunshot wounds of the spinal cord (*Brit. Med. Jour.*, 2:44, 1917), gives the following indications for operation at a casualty clearing station: 1. In the presence of incomplete paralysis of motion or sensation below the lesion especially. 2. If the roentgen ray shows displaced fragments of bone or the presence of a piece of metal in or near the cord, X-rays here often being very unsatisfactory. 3. When pain, due to pressure on the nerve roots, is excessive and uncontrollable. 4. When the character of the wound is such that sepsis, although not already evident, is likely to develop and cause rapid death. Other cases are to be evacuated and their operative future depends upon whether the surgeon in charge is conservative or radical.

Reitsch and Röper (Abstr. *Klin. M. f. Augh.*, v. 60, p. 710) write on unilateral mydriasis of sympathetic origin observed in wounds of the spinal cord, a condition which, in its lesser grades is not uncommonly seen in civil life as the result of irritative cervico-dorsal anomalies. Metzner and Wollflin (Graefe's *Arch. f. Ophth.*, Vol. 91, p. 167) discuss cervical sympathetic paralyses and Jickelli (*Klin. M. f. Augh.*, Vol. 56, p. 538) pictures a case of unilateral sympathetic paralysis caused by a bullet wound of the neck.

Roche (*Arch. d'Ophtal.*, Nov.-Dec., 1916) analyzes 11 cases of paralysis of the cervical sympathetic following projectile wounds. He tabulates the signs present in these cases under the heads of miosis, which existed in every case; ptosis, which occurred in 4; enophthalmos in 10; vasomotor disturbance in 6 and hypotony, which was not found in any case. Not one case presented the complete syndrome.

Cantonnet (*Arch. d'Ophtal.*, xxxv, 3) reports a case of a soldier who two months previously had been injured by a shell, a fragment of which had penetrated the left mastoid. The radiograms showed that the fragment had split into three pieces, which had lodged beneath the salient point of the left malar bone. The man presented the following syndrome of Claude Bernard-Horner—left eye exophthalmia; narrowing of the palpebral fissure; pupil contracted, with preservation of all reflexes; eye otherwise normal. The left cheek was in a condition of slight but marked atrophy. It showed a lowering of the local temperature, pallor, and slightly increased sweating, when the man exercised a little. Avellis' syndrome was also present: Complete hemiplegia of the left half of the velum palati; paralysis of the left vocal cord. There was also paralysis of the left hypoglossus, the left glosso-pharyngeal, and the spinal accessory nerves.

Cantonnet believes that in paralysis of the upper portion of the cervical sympathetic only oculo-motor disturbances, such as ptosis, miosis and enophthalmos appear, while disturbances of the sweat glands and of the circulation are found, as well, in lesions of the lower portion of the sympathetic. The point, however, is not proven by his case and will require the collection of numerous data before accurate laws replace surmise.

Von Szily (*Atlas,* p. 475) pictures and describes several cases of sympathetic lesions with ocular reflections.

Cassimatis (*Clin. Ophtal.,* vii, 1, Abstr.) describes the case of a soldier whose upper lip was perforated by a bullet which tore away a median incisor, coursed along the upper surface of the tongue, perforated the anterior faucial pillar and emerged behind the ear. No ill result occurred until about a month later when the eye was found red, seemed smaller than its fellow and was blind. Several weeks later the observer noted typical right-sided paralysis of the sympathetic evidenced by slight ptosis of the upper lid, redness of the conjunctiva and corresponding cheek, and moderate miosis. As the fundus was without a lesion and the reactions of the pupil were almost normal, a diagnosis of superadded hysterical amaurosis was made and confirmed by a partial return of vision to the affected eye.

It is of interest to note that, according to spinal localization, certain characteristic symptoms have been observed in projectile injuries of the region in which the sympathetic trunks may be affected to the point of ocular involvement; hyperthermia in the superior cervical cord, 104° Fahr. having been seen with injury of C4; at D1 and D2 marked and persistent increase in the pulse rate have been noted; in the mid-dorsal region, uncontrollable vomiting; and an inferior cervical syndrome has been described characterized by hypothermia, slow pulse, lowered arterial pressure, scanty urine and a general state of stupor.

Josue and Heitz (*Archiv. des Maladies du Coeur,* Sept., 1915) note the participation of the cervical sympathetic in paralysis of the four last pairs of cranial nerves on the same side, the simultaneous involvement of which was first observed by Sicard and Pollack in 1912. Villaret (*Presse Méd.,* 21, Nov. 1918, p. 591) united this last symptomatic ensemble under the title of the "nervous syndrome of the posterior parotid space." Faure-Beaulieu (*Presse Méd.,* 21, Nov. 1918, p. 591-593) has published an interesting study of two such cases. d'Oelsnitz and Cornil (*Bull. Soc. med. de Paris,* Jan. 1919) depict a syndrome similar to those described by the preceding authors but with the additional paralysis of the seventh and eighth cranial nerves of the same side, a case not greatly dissimilar to one reported by Morestin (*Bull. Soc. de Chir.,* Jan. 5, 1916, p. 145). In the case of d'Oelsnitz and Cornil the projectile penetrated the right external auditory meatus, caused a direct lesion of the right facial nerve at its exit from the stylo-mastoid foramen, damaged the internal ear by indirect traumatism, penetrated the posterior retro-parotid space and lodged in the quadrilateral formed by the junction of the horizontal and ascending branches of the left inferior maxillary. Here it had caused no vascular lesion but had damaged the four last pair of cranial nerves as well as the corresponding cranial sympathetic. The eye signs were lagophthalmos, Bell's sign and tearing due to partial eversion of the right lower punctum, enophthalmos, miosis, lowered tension in the right eyeball, diffuse redness of the right cheek and ear and an increase of local heat.

In view of the possible relation of the cervical sympathetic to heterochromia iridis and to certain forms of glaucoma it is worthy of note that no acute or terminal ocular involvement of this sort has, as yet, been reported as a sequel to these injuries of the sympathetic in the neck.

Monbrun (*Arch. d'Ophtal.*, May-June, 1916) reports six cases of a syndrome which appeared several months after a wound of the eye and orbit and in which portions of the ocular stump remained. This syndrome consisted of severe pain, constant, hemifacial, hemicranial, or involving the entire head. The pains presented a constant characteristic, being accompanied by a sensation of heat which rose to intense burning at times. These painful sensations were accompanied by vasomotor and secretory phenomena, consisting of a constant vasodilation of the entire face and ears, or only unilaterally or even more limited, accompanied by an outpouring of perspiration in the painful and vasodilated region. These symptoms, though constant, were subject to crises of exaggeration produced by slight physical effort or mental emotion. There were no trophic disturbances. Weir Mitchell, who studied traumatism of nerves particularly during the Civil War, coined the term *causalgia* for such heat pains. Based on analogous phenomena, observed in wounds of nerves in other parts of the body, Monbrun ascribes the phenomena to a lesion of the sympathetic fibers involved in the affected area, although he has not succeeded in relieving the symptoms by enucleating the stump. He suggests that his failure may have been due to his not having enucleated the sympathetic ganglion or that the ascending sympathetic neuritis had reached a point beyond the apex of the orbit.

Mougeot and Duverger discuss the *oculocardiac reflex* in wounded men. Of 190 who had been wounded in the eyes 5 developed bradycardia probably from concussion, which may be produced by hypertension of the cerebro-spinal fluid. They believe that if the reflex disappears after trepanation organic lesions must be assumed, but that if it reappears, the disturbances must be functional. Oppenheim could find no regularity of the phenomenon in 47 men who had sustained concussion of the brain and in 87 whose cranial condition had required trepanation.

The mode of production of *exophthalmic goiter of war* is not yet determined but whether this dramatic condition represents an endocrine imbalance primarily of psychic origin, or a local sympathetic disorder from the spinal malalignment and muscular hypertension seen not rarely in states of extreme fear, is not yet clear.

Viewed from the standpoint of endocrine imbalance, Etienne and Richard (*Bull. Soc. Med. des Hop.*, Paris, Dec. 20, 1918) relate that the repeated violent bombardments of Nancy from the big guns and aëroplanes enabled them to study the effect on the endocrine glands of emotional stress. In two women of 24 and 34, exophthalmic goiter developed in an acute form with high blood pressure. In two other young women the blood pressure was below normal. They note further that in some women menstruation was arrested by a bombardment; glycosuria was brought on in other cases. In one man of 36, symptoms of Addison's disease appeared and these were followed by the symptoms of exophthalmic goiter. These latter symptoms subsided in three months but the Addison symptoms persisted to a fatal termination in about eighteen months from the first signs of trouble. The nervous crises appeared first, in this case, after the destruction and bombardment of La Courneuve at Paris, close to his home. In four days the skin showed bronzing, with patches on mucous membrane, rapid pulse and low blood pressure. This case corrobates the possibility of an emotional origin of Addison's disease, as has been demonstrated for cases of exophthalmic goiter under similar stress. In two other cases Addison's disease became superposed on preëxisting exophthalmic goiter. Exophthalmic goiter of emotional origin may thus develop under the influence of suprarenal hyperfunctioning, but it can also develop with suprarenal hypofunctioning, and suprarenal trouble may also become superposed on exophthalmic goiter. In two cases of this latter type, the bronzing was extreme, but one man was still at work ten years later, and all the symptoms had subsided in the other.

THE PSYCHONEUROSES OF WAR.

The psychogenous disturbances and injuries incident to warfare include the usual hysterical and neurasthenic manifestations seen in civil experience and the more characteristic traumatic psychoneuroses, miscalled "shell shock," which have been aptly called "peace-time neuroses with a war-time coloring." In no previous war have such a vast number of men been disabled by functional nervous disease, the factors leading to this end being the induction into military service by conscription of great numbers of men with familial or personal psychic deficit phenomena; the unfitness or inability of these men to make the necessary mental and environmental adjustment to military service in camp and field; the exposure of such subjects to the continuous effects of high explosives, poison gas, airplane attacks, and all the other developments of scientific barbarism, and the terrifying effects of modern trench warfare. The large proportion of the male population of a highly civilized country which possesses a neurotic or neuropathic predisposition is shown by Salmon's statement (*Mental Hygiene*, Oct., 1917) that mental and nervous functional diseases were together responsible, up to 1917, for not less than 1/7 of all discharges for disability from the British Army, or 1/3, if discharges from wounds are excluded. According to Cushing, the French compute that 25 per cent. of war disabilities represent neurologic problems. Early in the war it was recognized that these diseases endangered the morale and discipline of troops in a special way and that the best manner of meeting the situation was by rejecting such conscripts or enlistments and in dismissing them from the service at once when recognized. An exact psychiatric diagnosis was not necessary for the determination of the defect but if the applicant appeared to be a social or economic problem, it made no difference whether this was due to tuberculosis, dementia precox, feeble-mindedness, abnormal personality, or what not, so long as the normal troops should not be exposed to the contagion, it being an elementary military fact that herd instinct, like anger and fear, is a factor of importance both for good and bad morale and that this morale is largely dependent on the instinctive suggestibility of man.

The incidence of such great numbers of cases of psychoneuroses and the mass study of their characteristics, promptly led to the elucidation of their mechanism of production as well as of the means of their cure, and showed their outstanding features to be that 1. Psychoneuroses, particularly of the traumatic variety, usually do not occur save where the individuals show familial and personal evidence of neurotic defects and biological inferiority; 2. The majority of such defects do not become evident at once after exposure to trauma but require an appreciable period of time for the accumulation of the novel emotive sensations to the point of their fixation and their final external expression in some characteristic form as blindness or deafness or muscular spasms; 3. These psychoses seldom appear among the wounded or among prisoners and great numbers of cases became much more easily suggestible for cure upon the declaration of the armistice; 4. Strong suggestion, properly led up to, and applied at the earliest possible moment by qualified men, is both preventive and curative of the symptoms, though, obviously, it has little or no effect upon the underlying psychic deficiency.

Salmon's comprehensive essay (*Mil. Surgeon,* Dec., 1917) states that there is a much higher rate of mental disease among soldiers, even in peaceful mobilizations, than among civilians, and that military life has well been called the "touchstone of insanity," a fact of importance when it is considered that this occurs among the younger generations of men and at an age less dependent upon organic cerebral changes. The discharge rate in the U. S. Army in 1916 was three times the admission rate for these disorders in the adult male population of the State of New York, 1/10 of all discharges being for mental disease, mental deficiency, epilepsy and the neuroses.

In military life the individual who, with much assistance, only barely succeeds in making satisfactory adjustments to civilian existence, is here thrown on his own meager resources. All kinds of personalities, some of them unable to adapt themselves to life under the best of conditions, must fit into the one iron mould which experience has shown to be that best fitted for the stern business of war. The logical result is a heavy incidence of those varieties of mental shipwreck called the psychoses and neuroses, and the merciless disclosure of a large number of constitutionally inferior individuals. Military life does not provide a favorable environment for the constitutionally psychopathic.

Early in the war the unfortunate term "shell shock" was applied to any form of nervous symptoms developing after exposure to shell fire that could not be explained by some obvious physical injury and was stretched to include even such well known forms of mental disease as general paresis and dementia precox. As Mott says, "It was a natural conclusion, at first, that men who had been exposed to the unprecedented stress of bombardment should suffer from commotio cerebri. But a great many returned as suffering from shell shock would have been more appropriately designated 'shell shy.' It was extremely difficult to differentiate commotional shock from emotional shock, for both may be attended by unconsciousness and followed by hysterical or neurasthenic symptoms. Still there was no doubt that men suffered from commotional disturbance of the brain without any signs of injury on the body and were the subjects of organic changes, due to the forces generated by the detonation of high explosives. This was proved by the fact that the cerebrospinal fluid, withdrawn by lumbar puncture, contained blood and came out under pressure. Moreover, the frequency with which rupture of the drum of the ear, deafness, labyrinthine changes, and voltaic vertigo occurred showed that the explosion was sufficient to cause a commotion of the brain as severe as might be caused by a blow on the head. Further proof was the fact that microscopic hemorrhages had been found throughout the brain in cases with no visible sign of injury on the body. These cases were commotional shock, as against emotional shock. On the other hand, a soldier born with or having acquired emotivity tended sooner or later to develop one or other form of nervous complaint. A shell burst near him and he saw the flash and was blinded by it, and remained functionally blind; he heard an explosion and was temporarily deafened by it and remained deaf, this being in a sense a method of defending himself against unbearable sights and sounds.

"Cases might, of course, occur in which both commotional and emotional shock were present. Though a neuropathic tendency greatly assisted the onset of shock, this might occur in sound individuals. The instincts connected with the emotions of fear and anger were all-important, but equally so was the herd instinct, and morale, good or bad, in a regiment was largely dependent on the instinctive suggestibility of man. A British general was reported to have said: 'Ten per cent. of a regiment will follow you to the gates of hell; 10 per cent. will fall down or run away; and the remaining 80 per cent. will follow either.' It might, therefore, be supposed that in the 10 per cent. who followed anywhere, the primitive emotion of anger, with its instinctive reactions, was inborn and dominant in the personality, and that to fight was the instinctive reaction of self-preservation in these men. But, in modern trench warfare anger was impotent. The soldier could neither fight nor run away. He could only crouch and hide himself, the instinctive attitude of the timid animal when threatened with danger."

Among the cases exposed to shell-fire is a large group in which, with or without damage to the central nervous system, a damage of which no actual proof can be adduced, the symptoms are those of the neuroses familiar in civil practice, colored in a very distinctive way by the precipitating cause and altogether dominating the symptoms which might possibly be referred to injury of the central nervous system. It is about this group that so much controversy exists, some holding them to be "injuries of the central nervous system without visible injury," while others term them "traumatic neuroses." Again others feel that psychogenetic factors determine not only the continuing neuroses but even the initial unconsciousness or special sense disturbances in these cases. The final group is one in which the slightest damage to the central nervous system from the direct effect of explosions is exceedingly improbable, many of such cases occurring among the non-expeditionary forces and called by Farrar "anticipatory" neuroses. In these cases the symptoms, course and outcome correspond with those seen in neuroses in civil practice. Of the possible physiological basis for the disorders of the last two groups little if anything is known, yet these groups are by far the largest and most important and the psychological factors in association are not to be ignored. It is known that war neuroses occur in striking excess among officers, being 1.6, while the ratio of officers to men among the wounded is but 1.24. Also war neuroses are rare among prisoners exposed to mechanical shock and equally rare among the wounded similarly exposed. Severe war injuries to the brain and spinal cord are not accompanied by symptoms similar to those in shell shock, in which injuries of less degree are assumed. The symptoms exhibited in these groups correspond more nearly to the existing psychological situation than they could possibly bear to the localization of a neurological injury. Thus a soldier who bayonets an enemy in the face develops a hysterical tic of his own facial muscles. Hysterical abdominal contractures occur in men who bayonet enemies in the abdomen, hysterical blindness follows witnessing particularly horrible sights, hysterical deafness appears in those who have found the cries of the wounded unbearable and men detailed to burial parties develop hysterical loss of the sense of smell. The psychological basis of all of these neuroses of war (like that of the neuroses in civil life) is an elaboration, with endless variations, of one central theme—*escape from an intolerable situation in real life to one made tolerable by the neuroses.* Either a function is lost, the absence of which releases the patient from the intolerable situation, or one is lost which interferes with successful adaptation, the function being either mental or physical. In the case of the severely wounded and prisoners, the war is over for them. Among 60,000 French prisoners captured in the terrific fighting around Verdun, Morchen found but eight cases of "shell shock."

Often soldiers suffering from neurotic symptoms based upon events in their personal lives of a non-military nature have been subjected to intense emotional strain without rest or relief for weeks. In war outward manifestations of this slowly accumulating stress must be sternly repressed, especially in officers. Unless the situation is unexpectedly relieved he suddenly presents all the acute symptoms of the condition known as "shell shock," but which, in fact, is usually the climax of a train of symptoms which have been moving to this end with greater or less rapidity. A very striking feature of the war neuroses is the relatively large proportion of men of apparently normal makeup and without previous neuropathic manifestations who develop them under the stress of war. Many of these men are volunteers.

There is a distinctive distribution of the different types of war neuroses with reference to rank. Among officers neurasthenic symptoms appear, such as great bodily and mental fatigue, irritability, anxiety and vague but persistent fears not commonly associated directly with the military situation. Cardiovascular symptoms are frequent in these types. Less commonly, but appearing more frequently among officers than among the enlisted men, are the compulsions and obsessions which make up the clinical picture of psychasthenia.

Gross sensory and motor symptoms of hysteria such as hysterical paralysis or tremor are much less common among officers though they rarely occur, and reversely, neurasthenic and psychasthenic symptoms are much less frequent among the enlisted men, among whom mutism, violent tremors and tics, contractures, etc., are more frequent.

In those cases which have as their starting point a definite shell or mine explosion there are often symptoms which suggest concussion. Unconsciousness, dizziness, deafness, blindness, motor incoordination and such psychical symptoms as amnesia, confusion and hallucinations of hearing make up the so-called "concussion syndrome." This phase occurs in action and often it is significant that unconsciousness does not come simultaneously with the explosion but when some emotional reaction occurs, such as the sight of the mangled bodies of his comrades around him.

Often an interval of hours or days intervenes between the shock-producing stimulus and the development of a traumatic psychoneurosis such as hysteria. The French say "there is no hysteria in the firing line;" time must elapse, though it be measured but by hours, for subconscious complexes to be formed—"une période de méditation" is necessary, a subconscious rumination. This mechanism has been demonstrated in so large a number of cases as to be commonplace.

That traumatic neurasthenic symptoms, however, may immediately succeed a shell explosion or a direct injury, such as being buried, is recognized by all who have been working on the neurological side of the injuries of warfare, but a distinction must be drawn between neurasthenic manifestations and hysterical manifestations. Restriction of the visual fields and helicoid curves, without being in the strict sense pathognomonic, are characteristic of the latter condition.

The protracted phase of the war neuroses is closely associated with continued hospital treatment. Results which are little short of miracles are obtained when it is possible to treat these men in advanced stations but when they are passed back from hospital to hospital and exposed to misdirected harshness and equally misdirected sympathy they most often acquire a train of "secondary symptoms of war neuroses" and thereby add to their initial neurological disability, of a distinctly removable type, such secondary effects as unfavorable habit reactions, stereotypy and fixation of symptoms, and the self-pity of the confirmed hysteric, the morbid timidity and anxiety of the neurasthenic and the despair of the hypochondriac. Exposed to protracted life in hospitals and especially in convalescent homes inactivity and aimless lounging weaken the will and quickly permit the attitude of permanent invalidism to replace that of hope and of recovery. The symptoms of the traumatic psychoneuroses appear in widely separated fields.

Psychical symptoms include transitory delirious states, amnesia, mental confusion, hallucinations and "battle dreams" of hallucinatory vividness, of fear and horror. Disorders of speech include aphasia, stammering mutism, and aphonia. Sensory symptoms are anesthesia, which is present in nearly all cases, showing somatic signs, pain and hyperesthesia. Any of the special senses may show anomalies. Blindness, night-blindness, deafness or hyperacusis and anosmia are common. Disturbances of gait, contractures, and local or very extensive paralyses are especially frequent. *There are few hysterics among the military cases in whom some types of tremor do not exist.* Loss of motor control is often startling and a slight sound often provokes a sharp reaction in patients who seem to be well on in convalescence. Disturbances of involuntary function include tachycardia, enuresis and diarrhea.

In the diagnosis of functional nervous diseases much weight should be given to the general attitude of the patient, especially his attitude toward his disability. His excessive interest in his symptoms, his over-suggestibility, his self-pity (which may, however, be concealed under a highly artificial assumption of indifference) and the precise relation which his disorder bears to the personal and military situation in which it occurred, are very important. It is desirable to reconstruct the chronological development of the disease, for its long duration on the one hand or its sudden onset on the other will very often aid in positively excluding the existence of organic disease. Emotional disturbances are common in the neuroses, but emotional changes accompany organic nervous diseases, especially multiple sclerosis and those in which the central nervous system sustains gross damage as in cerebral hemorrhage or trauma. Those seen in hysteria are familiar. The presence of hysterial stigmata, of which the patient is unaware, especially hysterical eye symptoms and anesthesia will often help as much in diagnosis as the scrutiny of specific subjective or objective signs. The topical diagnosis between hysterical symptoms and the different organic nervous symptoms covers a wide field of clinical neurology. Aphasias are always paradoxical and accompanied by other hysterical symptoms. Stammering comes on suddenly with no history of similar speech disturbance in youth. Aphonia may be shown to be functional by a careful laryngological examination. *Visual symptoms do not correspond to any organic cerebral lesions and the eye is found to be normal except for contraction of the visual fields especially in the helicoid form so characteristic of hysteria.*

Paralyses may resemble superficially any type seen in organic nervous lesions but never accurately, as the distribution of local paralyses seems never, even by accident, to correspond exactly to that due to lesions of nerve roots or peripheral nerves.

Bonnal says "The hysteric is a malingerer who does not lie." The cardinal point of difference is that the malingerer simulates disease or a symptom which he has not in order to deceive others. He does this consciously to attain through fraud a specific selfish end, usually safety in a hospital or discharge from the military service. He lies and he knows that he lies. The hysteric deceives himself by a mechanism of which he is unaware and which is beyond his power consciously to control. He is usually not aware of the precise purpose which his illness serves. This is shown by the fact that, in many cases, all that is necessary for recovery is to demonstrate clearly to the patient the mechanism by which his disability occurred and the end to which, unconsciously, it was directed.

The psychogenetic disturbances of the eyes which occur in the various psychoneuroses of war may be classed, according to the division suggested by de Schweinitz, into (1) the amblyopias and amauroses, including the characteristic contracted and helicoid fields and the inversion of the color fields, types which in civil experience have been considered as incomplete and complete anesthesias of the visual sense; (2) asthenopias and anomalies of accommodation; (3) anomalies of the movements of the iris, i. e., pupillary phenomena; (4) anomalies of movement of the eyelids and extraocular muscles and (5) cases which cannot be included in any of the foregoing groups.

The disturbances of vision which appear may be objective or subjective. In the former the patient may see flashes of light or spots and clouds before his sight or objects appear larger or smaller than they should, owing to accommodative disturbance. At times images which are usually suppressed become apparent, as for example, the man may complain of seeing his nose, or after-images may be of long duration or a host of other purely subjective disturbances may be complained of. In the visual fields concentric contraction for small white and colored test objects may be demonstrated but normal central vision be retained. Where the subject is easily fatigued a progressive contraction of the field for white and colored test objects may produce characteristic helicoid curves, in the form of diminishing spirals. In conjunction with contracted fields some reduction of central vision may be claimed although, as Holden states (*Arch. Ophthal.,* May, 1918, p. 239) by forceful urging many can be induced to read the test letters as far down as their refractive condition should permit them to read. In others a fixed diminution of central vision may accompany a fixed defect of almost any character in the fields of one or both eyes. These defects, both of vision and of the visual fields, are likely to have been suggested by the examiner who first had the patient in charge and to have become fixed in the patient's mind at that time. In some cases more or less complete blindness is said to exist in one eye but this can usually be unmasked by some form of test for malingering. In a certain few cases a condition of apparently complete blindness exists in both eyes. This condition is usually a defense reaction against something which he wishes to avoid seeing or against some task from which blindness will relieve him. In all these cases the optic discs and fundi are normal in appearance and the pupils usually react though with some sluggishness. The functional nature of these situations is betrayed usually by the lack of coöperation of the patient in turning his eyes. If directed to turn them to the right, for example, he apparently makes a great effort to move them in that direction but, in reality, the effort is applied to prevent the eyes from turning in that direction. The presence of corneal hypesthesia and of other functional data, his recent psychic experiences and his obvious desires all aid in confirming the diagnosis.

In the matter of inhibition of vision, apart from hysteric amblyopia, Hurst and Syms, writing in the admirable *Seale Hayne Neurological Studies* (Nov. 1, 1918, 1, No. 3) report that they have never seen patients with hysteric symptoms, who spontaneously complained of disabilities resulting from a narrow field of vision. They have examined numerous soldiers suffering from various war neuroses, but have never found any retraction of their field of vision until they were tested with the perimeter. They claim that the perimeter invariably resulted in the suggestion of a narrowed field. If the examination was continued after the first field had been marked out, a spiral field was always obtained, identical with that which has hitherto been regarded as a stigma of hysteria. This has not been found oftener in hysteric cases, simply because it has not been looked for. An outward spiral is always obtained instead of an inward one, if the white disc of the perimeter is moved outwards instead of inwards, as is commonly done.

In the course of some investigations on "experimental malingering," twenty-seven individuals, who were pretending that they were paralyzed on the right side as a result of a railway accident, were asked whether they could see as well with the right eye as with the left. Seven replied that they had noticed some impairment of vision in the right eye. On testing the field of vision with the finger, no narrowing was observed, but when tested with the perimeter, all of the seven showed a narrowing on the right side, and one had a slight narrowing on the left.

Holmes, Uhthoff (*Münch. med. Woch.*, Jan. 15, 1918, p. 80), de Schweinitz, Wilder and others have noted the complete abolition of the color-sense, apparently from traumatic psychoneurosis.

The majority of the functional visual disturbances consist of varying forms of spasm of the voluntary ocular muscles, blepharospasm, associated with photophobia and "burning eyes" being in the foreground, and taking the forms of tonic or sphincteric clonic contractions which produce either a complete closure of the lids or, in the lesser degrees, more or less drooping of the upper lid. That this is spasmodic and not paralytic is usually clearly shown by the patient's resistance to forced raising of the lid. In common with many of the forms of functional nervous visual disorder the spasms and photophobia frequently arise from, or in connection with, minor ocular traumas, such as relatively harmless injuries from foreign bodies or slight exposure to irritant gas, the local irritation serving as the focus of the local, and finally of the more generalized symptoms. An instance of this sort is graphically depicted by von Szily (Fig. 377 and 378, p. 505, *Atlas der Kriegsaugenheilkunde*) showing orbicularis spasm which followed superficial grenade injuries and the evidence, in terms of facial expression, of the psychosis which was generated from this simple origin. The type and direction of other muscular spasms, such as those of the internal recti by which tonic convergence and variable diplopia are produced are probably determined to a considerable degree by the preponderance of muscle action, or muscular imbalance, which existed before the injury although in part they may have been guided to their peculiar localization by memory-pictures which had been especially distressing in civil or recent military experience.

Yealland (*Hysterical Diseases of Warfare,* London, 1918) discussing functional spasm of accommodation, functional blepharospasm and functional amblyopia divides hysteric disorders clinically, into two groups: (1) Conditions in which contraction of antagonists could be demonstrated; (2) those in which this could not be demonstrated. By contraction of an antagonistic group of muscles he means the contraction of a group which should be relaxed during the performance of a given movement, as illustrated in blepharospasm, ptosis and spasm of accommodation.

With a simultaneous contraction of the orbicularis and the levator, for example, failure of the sphincter to relax prevents the opening of the eye and hence causes apparent loss of vision. The action of the antagonists in spasm of accommodation could be explained by the assumption that the suspensory ligament of the lens performed an opposite action to that of the ciliary muscle, the normal state of tension of the suspensory ligament being altered only by the contraction of the ciliary muscle whereby the ligamentous tension is relaxed. The phenomenon of contraction of antagonists cannot be demonstrated in such conditions as limitation of the visual fields and amblyopia, but in these conditions, contraction of antagonists in some other part of the body could be observed. The treatment is one of suggestion and should be completed at one sitting. In Yealland's experience it produced complete relief of the physical disability, though much could not be hoped for in improvement of the mental state.

Loehlein (*Klin. M. f. Augh.*, 56, p. 541) describes a psychogenous paresis simulating a bilateral paresis of all of the extrinsic muscles of the eyes. The soldier, who had collapsed psychically under the stress of battle, suffered from headache, dizziness, insomnia, was impassive and timorous and had twitching of the facial muscles, but understood what he was about. Aside from the assumed complete immobility of the eyes they were normal. The absence of a true paresis was shown with ease by directing the patient to fix on an object held in front of him and then rotating the head unexpectedly to the side, when the eyes automatically turned to follow the stationary object. Considerable improvement in the voluntary movements followed this demonstration gradually.

Weisenburg (*Jour. A. M. A.*, Aug. 23, 1919, p. 596) describes the following case: A boy, aged 18 years, with a normal history, after a particularly trying attack which lasted many days, and in which many of his companions were killed, began to develop a tremor all over his body with quick jerking movements of the head and a constant dancing of the eyeballs to which his lieutenant called his attention. This was in April, 1918. His tremors gradually lessened, but the movements of the eyeballs continued. It is interesting to note that besides having been gassed he had a flesh wound in the left leg, and a rifle bullet wound in one shoulder. Examination did not detect anything unusual, with the exception of quick reflexes; but there was present a constant horizontal nystagmus, which greatly increased under excitement, and almost disappeared when the patient was at rest or when free from exciting stimuli, and was absent when he was asleep. The ocular movements were quick and of wide range, and were different from the nystagmus seen in multiple sclerosis or any other disease.

The reporter makes the pregnant comment that "There is no reason why there should not be a hysterical tremor in the eyeballs, just as well as in any other part of the body, but that such a thing is possible, is interesting."

Other observers have reported cases of coarse lateral nystagmus, not aggravated by looking up, as in the case of miners' nystagmus, and appearing alone or associated with other ocular symptoms.

That many cases of defective vision which are diagnosed as the product of "shell shock" are in fact the result of visual loss from preexisting gross organic lesions or refractive conditions made manifest through nervous shock, as occurs not rarely in civil experience, is well known, and at times so minute but essential a cause of blindness as a diminutive lesion in the macula has been overlooked and miscalled traumatic amblyopia of psychogenetic origin. Evans (*Trans. Ophth. Soc. U. K.*, 1916) illustrates this point by the following:

Analysis of 50 cases in which failure of vision was ascribed to the bursting of high explosive shells.

Cause of the visual defect.	Number of cases.
Errors of refraction	13
Corneal lesions: nebulæ following local injury	5
" " keratitis or epithelial dystrophia	5
Conjunctivitis	5
Iridodialysis	1
Subluxated lens	1
Choroidal rupture	2
Retina: hole at the macula	2
" (?) thrombosis of the central artery	1
Optic nerve: hemorrhage into sheath or nerve	1
" " atrophy	2
Paralysis of the cervical sympathetic	1
Convergent strabismus (alternating concomitant)	1
Old-standing diseases (tabes, cataract, squint)	3
Normal eye	1
Doubtful cases, probably malingering, but possibly hysteroneurasthenia	6

Hurst and Ripman (*Seale Hayne Neurological Studies,* Nov., 1918) write interestingly on the hysterical ocular symptoms of photophobia, blepharospasm, etc., complicating conjunctivitis and particularly that form of conjunctival irritation produced by gassing and which is often of considerable duration.

The prognosis of psychogenous battle injuries corresponds in general to that of war hysteria although it must be considered rather less favorable as regards the final outcome. Even after a cure such patients should not be returned to the front and while some could be utilized for garrison duty they are best discharged as unfit for military service. The majority are perfectly competent to resume their civilian duties though in the few cases where the emotional crisis has left deeper psychic scars and the old civilian existence is obviously impossible a special disability indemnity is clearly indicated, as well as continued psychiatric oversight and care.

The treatment of the war neuroses is essentially a problem of psychological medicine. In the great majority of these cases the completeness, promptness and durability of the recovery depend upon the insight shown by the medical officers under whose charge the soldiers come and their resourcefulness and skill in applying treatment.

There is one point upon which all experienced men are united, namely, that the treatment must be instituted at the earliest possible moment. Hesitation and tentative steps spell disaster. The physician must act promptly, perhaps swiftly, always with confidence, often with emphasis. This he cannot do unless he knows he is right, and he cannot know he is right unless he is familiar with organic and functional disease of the nervous system and has made a thorough examination. Wrong treatment is worse than no treatment. The mind of a victim of recent "shell shock" is well likened by Frost (*Mil. Surg.*, Apr., 1919) to freshly mixed plaster of Paris. The lightest touch will make an impression either for good or ill, which in a few moments becomes fixed and hardly is to be changed. Correct treatment during this initial plastic stage effects cures which are little short of miracles, just as casual adverse suggestions, or failures of well-meant but ill-advised treatments will crystallize and fix existing disabilities and add thereto many new ones. For the same reasons, fresh cases should never be sent far to the rear, for this course carries with it the suggestion of a long convalescence, while the retention of the spirit of army discipline is an important aid. As Salmon (*loc. cit.*) clearly points out the worst possible place to treat such a case is in his home town where, in so far as the more striking objective symptoms are concerned, the sympathetic commiseration of friends and relatives creates a positive demand which the ideogenic factor of the patient's illness continues to supply faithfully.

Early in the treatment the patient should be guarded against chance suggestions and unguarded diagnoses and should be made absolutely comfortable, with narcotics if necessary, until seen by a qualified neurologist, and whatever disability exists should be carefully explained as an evanescent phenomenon, quite usual in these cases, and of no permanence or importance. The majority of such cases are radically cured within 48 hours when treated with the requisite promptness and intelligence. Prophylaxis is, of course, the ideal treatment, beginning with the segregation of men of the "pre-shell-shock" type and employing them in situations where the pressure of army life is not likely to rise beyond their critical points of tolerance.

Roussy, Boisseau and d'Oelsnitz (*Traitement des Psychoneuroses de Guerre,* Paris, 1918) divide their procedure into (1) preparation; (2) relief from the motor trouble, "unhooking," "detachment," "uncoupling"; (3) fixation of the result obtained and (4) training, both medical and military. Of these they think the first the most important and its object is to procure the proper mental attitude.

The necessity of a correct diagnosis is, of course, basic, but with the establishment of the diagnosis of a psychoneurosis during which the confidence of the sick man is acquired, he is informed that he is curable and is going to be cured. The all-important preliminary now is the creation of a proper atmosphere. The nurse encourages the patient to believe that he will be cured as soon as the doctor has time to see him, tales of brilliant successes in similar cases are told him and he is placed in a ward with men convalescent from similar trouble. By the following morning the patient is fully convinced that the hoped-for cure will take place and as the medical officer is equally convinced, the two essentials for recovery are present. Not until the patient has reached "psychic maturity" is the next move taken, a move for which the physician must also be in good form, as it involves a mental contest between the patient and physician from which the latter must emerge as victor. Occasionally if the preparation has been imperfect the struggle may last two to four or more hours, but the physician is not to desist until his result is attained. Hurst and Syms (*Lancet,* Aug. 3, 1918, p. 139) showed in their earlier experiences that recent cases could generally be cured quickly and completely by a variety of methods such as simple persuasion and reeducation, suggestion with the aid of electricity, by hypnosis or by waking suggestion under light anesthesia, but occasionally cure was imperfect or incomplete. Even in hysterical aphonia or mutism, which almost invariably disappear after a few minutes' treatment, sometimes after having existed for more than a year, the more serious speech defect was often followed by a stammer which might require careful reeducation for several weeks before complete recovery occurred. It is common belief now that complete recovery should be reached within 24 hours after the commencement of the treatment and this must be carried to a cure in the first session wherever possible. "If a man with severe hysterical paraplegia of many months standing is taught to walk in half an hour and treatment is then discontinued because of his fatigue, although his gait is stiff and unsteady, he will probably not walk normally until he has undergone reeducation for a few weeks. But if the officer in charge ignores not only the patient's fatigue, but his own, and continues the treatment for another hour or even for two or three hours, the patient will end by walking with a normal gait." In the same way mute or aphonic soldiers, or those with blepharospasm or spasm of the interni who partly recover from their defect, should not be left until the cure is complete, or else a complete recovery will be reached only after several weeks of daily lessons. Simple persuasion has the great advantage of making the patient take an active part in his own cure. In the great majority of intelligent patients a clear, forcible explanation of the mechanism of their troubles and an effort to effect what Salmon calls "a thorough mental catharsis" for the relief of any latent pressure of unexpressed emotion, accomplishes a rapid cure. With unintelligent patients quicker, though no more decided, results may be obtained through hypnotism and counter-suggestion, although here, as with the intelligent, the cure must be followed up by reeducation of will, thought, feeling and function. It seems incredible that paralysis and contracture of the hand with "boxing glove" edema of 33 months' duration could disappear in 18 hours, or that coarse tremors of the head, facial tics, severe spasm of the lids and tonic ocular muscle spasm lasting many months could disappear in an hour or two, but the results of all experienced neuropsychiatrists confirm these remarkable cures and bring to civil practice the means of surcease from the hitherto neglected and much misunderstood traumatic psychoses of civil life.

An interesting observation has been made by Vischer (*Brit. Med. Jour.*, Apr. 26, 1919, p. 696) concerning the symptoms developing among prisoners interned for long periods. Careful observations of prisoners of war in Switzerland, lead Bing and Vischer to describe a very characteristic psychoneurosis to which has been given the symbolical title of "psychose due fil de der barbelé," in German "Stacheldrahtkrankheit" and in English "barbed wire disease." This name seems to have originated in Switzerland, though its exact origin cannot be certainly determined; it has established itself so thoroughly that already it is to be found in international treaties. The symptoms of a neurasthenia *sui generis* are recognizable in most of those who have lived for more than six months behind the barbed wire fencing, and which in about 10 per cent. of all prisoners reach a high level of intensity. The first sign to appear is an increase of irritability. There is a great deal of quarreling. The power of concentration is greatly diminished. The prisoners complain with striking constancy that they lose their memory of people and of places, in so far as these relate to prewar events. Among the secondary symptoms are insomnia. Some prisoners complain of diminished vision. Many of them grow very suspicious. All have a marked tendency toward pessimism, and see every incident of their daily life in the gloomiest light; the worst cases often go for three or four days without speaking a word, plunged in a kind of torpor. Sexual impotence is very common. All these symptoms, once they are established, generally remain stationary, and rarely diminish so long as the internment lasts. Disturbances of memory, especially amnesia, are very marked.

Ocular malingering. Those who allege, counterfeit, exaggerate, create or conceal disease in a military environment may be classed, according to Bailey (*Military Surg.,* March, 1918) into two groups: one containing those who do so with full knowledge, intent and responsibility; and a second group of which the members are hypochondriacs or constitutionally inferior individuals who throughout their lives have never been able to meet disagreeable situations without complaint and ruse, deceit and evasion. The first group, in the past war at least, has been small. Few cases have been brought to court martial, and the consensus has been that most of the malingerers had something the matter with them. For example, the medical service at Camp Hancock reports that "viewed from all angles, no patient could be accused of a deliberate attempt to deceive."

The second group contains the larger number. One surgeon expresses himself as convinced "that in almost all of the cases in which defects were simulated or exaggerated, the patients were actually defective either in a lesser degree, or in a different affection, or in both. Whether the malingering took the form of mental or nervous or physical defects it was based in almost every instance on an actual unstable or defective mental state."

The progress of medicine has altered the military aspect of malingering. It has rendered the act itself much more difficult of accomplishment and in this way has decreased the numbers in group one. Group two, on the other hand, has been enlarged, as the increase in number and accuracy of diagnostic methods, and the clinical recognition of glandular disorders, bone diseases, psychopathic states, etc., formerly unrecognized, has resulted in soldiers now being sent to the hospital who 25 years ago would have been sent to the guard house.

Salmon states that the distinctive points of difference between hysteria and malingering are: 1. The malingerer is conscious of his fraudulent intent and, being fearful of detection, dreads examinations, which are invited by the hysteric. The hysteric, in addition to the symptoms of which he complains, often presents objective symptoms of which he is unaware. The malingerer, unless of low intelligence, confines his complaints to the disease or symptom which he has decided to simulate. Malingering may follow a neurosis. The gravity of malingering as a military offense in the field justifies the recommendation that no case in which the possibility of a psychoneurosis exists be dealt with finally until the subject has been examined by a neurologist or a psychiatrist. The knowledge of such expert examinations always tends to discourage soldiers from this practice. Most men find in their ideals, temperament, character, their interest in their duties, their regard for the opinion of others or in the reactions acquired during their training, resources sufficient to combat with relative ease the urgings of the instinct of self-preservation or the desire to avoid disagreeable tasks.

Cases of malingering are by no means always easy to detect, for there is no sharp division between downright malingering, mere exaggeration, subconscious malingering and actual disease. In most cases detection of the malingerer resolves itself into a battle of wits between the surgeon and the patient.

Ocular malingering may be divided, according to the method of participation of the eye or the type of alleged defect, into: 1. Local expressions of factitious general changes; 2. Provoked conjunctivitis and 3. Feigned impairment of vision.

1. The most striking ocular evidence of a factitious general condition is that afforded by the ingestion of picric acid in order to simulate jaundice, a not uncommon subterfuge. Excesses of picric acid may produce actual poisoning and ophthalmoplegia, but in the usual light forms a moderate discoloration of the sclerotics, the skin and urine is induced. Chavigny (*Paris Méd.*, Aug., 19, 1919, p. 150) writing on factitious phlegmons and jaundice evoked in order to escape military service, demonstrates that picric acid dust, inhaled in the manufacture of munitions, does not pass into the urine and that even when used as an adulterant to food, it is never sufficiently concentrated to appear obviously in the urine. Hence when it is found pronounced in the urine in persons subject to military duty, this is presumptive evidence that it was taken to induce the jaundice which always follows.

Sgrosso (*Ann. di Ottal. e Clin. Ocul.*, Vol. 40, p. 533) states that Angelucci has introduced picric acid as a cure for provoked conjunctivitis with brilliant results, the deep tint of the 1 per cent. aqueous solution probably aiding materially in the successes obtained in all varieties of factitious conjunctivitis. Numerous other chemical agents and drugs have been ingested to the end of simulating disease, and among them belladonna and its alkaloids and aconite have been employed in various ways and with characteristic ocular signs which may confuse temporarily until the patient inevitably overplays his hand and furnishes the means for his own detection.

2. Provoked conjunctivitis has been rather common in the continental armies, Cirincione (*Policlinico*, June 10, 1917) finding 2,000 cases among 50,000 men inspected. The materials introduced into the conjunctival sacs in order to excite inflammation embrace all manner of foreign bodies from dirt, soap, castor oil, tobacco fragments and tobacco juice, pepper and tartar from the teeth, to such powerful

irritants as chrysarobin, jequirity, cantharides, ipecac, podophyllin, corrosive sublimate and copper sulphate. The effects of some of these materials is purely mechanical but in many cases in which stronger and unusual irritants are used the chemical irritation may be confusing temporarily. Suspicion will be aroused shortly, however, by the facts that the conjunctivitis is generally unilateral; that the conjunctival swelling and reaction are decidedly more violent than is seen accompanying the usual mild bacterial infections; that the lower lid carries the brunt of the inflammation; that bacteria are absent from the secretion, which is not muco-purulent; and that the characteristic sources of the inflammation may often be identified in the sac and its secretion or, as Rasquin (*Arch. Med. Belges*, April, 1917) naively suggests, in the patient's pocket-book, watch case or other personal vehicle. Corneal complications are seldom met with and the condition usually subsides after the eye is simply cleansed and sealed hermetically with a collodion dressing.

Parparcone (*Ann. di Ottal. e Clin. Ocul.*, Vol. 40, p. 533) records an instance of conjunctivitis, produced by nitrate of lead, which produced typical waxy elevations upon the palpebral conjunctiva, difficult to differentiate from some forms of conjunctivitis. In the experimental conjunctivitis which the observer produced in animals with this substance the superficial conjunctiva presented numerous points of greyish-white infiltration. These gradually disappeared after several months, without leaving any traces or permanent scars.

Histologic examination showed the following: Tumid infiltration, with necrotic degeneration of the epithelium and tissues which presented a total disorganization of the tissue protoplasm; recent swelling of the endothelium of the blood vessels which extended even into the smaller vessels of the same system; the presence and extension into the chorion mucosa of the crystals which were identified as crystals of nitrate of lead.

Cosse and Delord (*Ann. d'Ocul.*, cliv, 1) warn ophthalmologists to be on the lookout for conjunctivitis provoked by the introduction of pepper, tobacco and ipecac, and they describe the microscopic appearance of these substances as recovered from the conjunctival sacs. Fromaget and Harriet (*Ann. d'Ocul.*, cliii, 9) show that ipecac acts as a chemical irritant to the conjunctiva in the forms of powder, fluid extract and 2 per cent. solution of emetine, symptoms appearing in from 10 to 20 hours after their introduction. van Schevensteen (*Clin. Ophtal., Oct.*, 1916) refers to ipecac conjunctivitis which occurs either in acute or chronic forms, according to the single or repeated use of the powdered drug.

Sblordone has found that the ricinus seed is the substance preferred by some malingerers, a small fragment being introduced into the inferior fornix. The symptoms produced are edema of the eyelids, abundant purulent secretion, swelling and thickening of the palpebral conjunctiva. At some points of the lower lid whitish eschars are seen. The bulbar conjunctiva is chemotic, forming a ring around the cornea, sprinkled with numerous reddish points. In very advanced stages the upper portion of the conjunctival sac participates. The cornea remains unaffected. The subjective symptoms are slight.

Condorelli Francaviglia made experiments with the bean of the castor-oil plant. He has been able to produce a conjunctivitis by the use of different parts of the bean. In his experiments he employed the whole bean; the bean freed of its covering or skin, and collyria made from pulverized seeds. He came to the conclusion that the bean was a topical irritant to the conjunctiva, producing a mucopurulent conjunctivitis which differed from ordinary conjunctivitis of bacterial origin in its unequal distribution. The inferior palpebral conjunctiva and the corresponding portion of the cul-de-sac are intensely inflamed, while the bulbar portion participates moderately. In several cases there was marked edema. The congestion was of a flesh-color, in contradistinction to the scarlet-red of genuine conjunctivitis. Palpebral edema, more or less according to the inflammatory process, was present. Induced conjunctivitis is always monocular. The paste derived from the skin-freed bean excites a more prompt and energetic reaction than does the whole bean, or the collyria. For speedy preparation it is generally more convenient to use the pith, which can be easily done by the use of a spatula knife blade, and this will exclude the possibility of acute gastroenteritis by the handling of the castor oil beans and the transference of the substance to the mouth.

In the acute form the unilateral conjunctivitis is most marked in the turgid lower cul-de-sac. The secretion is slight, at times forming a layer in the form of a membrane which, however, is obviously a pseudo-membrane. The eyelids cannot be opened spontaneously and the skin about the lids often appears erysipelatous. In the chronic forms the characterisitic trachoma-like reaction produced in the conjunctiva by ipecac, and which has been noted by several writers, appears. The unilateral type is frequent and the lesion is confined to the lower cul-de-sac. The conjunctiva is smooth, with deep folds, a characteristic salmon tint, and the vascular tracery is lost. No organisms are found in the minimal secretion, the trachoma-like follicles, which sometimes appear at the upper border of the tarsus, disappear after the use of an occlusive dressing, and ipecac may be recovered from the sac. Kalt (*Ann. d'Ocul.*, cliii, 6) uses the method of rubbing the lower fornix lightly with a small swab of gun cotton, which is first dried in an incubator at 50° and then dissolved in a 1:2 solution of alcohol and ether. This is allowed to evaporate, a few drops of water are added and a second drying follows. The pellicle which remains is spread on a slide with a drop of water. Under the microscope the ipecac appears as dark masses which turn blue on adding Lugol's solution, thus demonstrating the presence of starch.

In consideration of feigned disturbances of vision, the report on this subject issued from the office of the Surgeon General, U. S. A. (*Mil. Surg.*, Apr., 1918, Vol. xlii, No. 4) is followed in its entirety:

"Malingerers who wish to avoid military service through feigning impairment of vision, may be divided into two classes: 1. Those who claim total loss of vision in one eye, and 2. those who claim a partial loss of vision in one or both eyes. Either group may have a normal acuity of vision, or may exaggerate a defect actually present.

"In civil life, feigning blindness in both eyes is not uncommon, but this is rarely met with in military experience, probably for the reason that blind persons are well known in their community.

"Refusal to read the test card is a favorite method of those who feign or exaggerate visual defects. Some of the men in this class actually have defects that would disqualify them. Others have slight refractive errors, or they have become familiar with the methods of testing with the types, while some have been coached to read only a certain amount.

"Frequently recruits will give long descriptions of injuries to the eyes, or of foreign bodies in them, and when subjected to an ophthalmic examination they will wink rapidly, turn their heads from side to side, and bitterly complain of the pain caused by the small light of the ophthalmoscope, even when held some distance from the eye. Quite a number deliberately close their eyes, declaring they cannot open them. Rarely they feign complete blindness, but on inquiry it will be found that they have been able to follow an avocation and that they walked unaided to the place where the examinations were held.

"In addition to feigning failure of vision, occasional diseases of the lids will be claimed, which, upon investigation will prove to be either an irritation produced by placing an irritating substance in the eye, or by partial loss of vision through the use of atropine or other drug, which temporarily suspends the power of accommodation.

"As a matter of experience, a recruit with a serious inflammatory disease which might jeopardize his sight practically never exaggerates the symptoms, while the effects of slight chronic conditions, like scars in the cornea or a refractive error, neither of which would reduce the vision below the required standard, will be grossly exaggerated.

"Men with inactive trachoma sometimes will call attention to their years of eye trouble, and describe the treatment they received at well known eye hospitals, often supplementing their complaints with letters and certificates.

"At Camp Sherman malingerers were classified as follows: 1. Cases of normal or nearly normal vision in one eye, with total or nearly total loss of vision in the other. 2. Cases that claimed defect of at least 6/30 in one eye, and 6/12 or better in the other. 3. Cases in which each eye falls below the requirements. 4. Excessive blepharospasm or other symptoms that prevent the use of their eyes for duty.

"*Detection and management.* Tests are of two types one, the more valuable, which aims to reveal the exact visual acuity and the less important, which is intended to impugn the honesty and credibility of the subject. The first class of cases can usually be detected by the 'trial frame test' (Regulation Class B—test b). The second class is frequently detected by the mirror test (Regulation Class B—test a). The third class is usually the most difficult to handle because it includes the pretender who has studied the subject and obtained from fellow soldiers all the information possible regarding the methods of testing. He is accepted, however, in the absence of objective evidence, and when the use of the retinoscope reveals no refractive error sufficient to account for the visual defects. Cases in class 4 are usually put in the hospital and watched."

Irritated lids usually recover under soothing lotions while blepharospasm yields to a strict diet, confinement in bed, unpleasant internal treatment, use of bandages, or, in rare cases, preparation for operation. In one unusual case a man claimed to be unable to open his eyes sufficiently to permit of examination because of the pain produced by the light. He was ordered to wait until he would submit to operation and after endeavoring to keep his eyes turned down for three hours, his nerves broke and he submitted to an ophthalmoscopic examination and a visual test which gave 6/6 with each eye, although he had acknowledged to but 6/30 with the right eye and light perception in the left at his first examination.

Lagrange (*Arch. d'Ophtal.*, xxx, 4) relates the story of a soldier who became unconscious after having seen a comrade struck by a bomb, and who, on waking, pretended to have become wholly blind. No abnormality was found on examination but the simulation of blindness persisted for fifteen months when it was finally mastered by guaranteeing a cure by a serious operation upon the brain or, if this were refused, he was to be reported as a malingerer. Vision recovered after the eyes were washed under light general anesthesia. This case might be classed equally well among the psychoneuroses.

It is impossible to formulate a set of rules which will enable the examiner to detect malingerers in a routine manner. He soon learns to observe carefully the manner, attitude and general bearing of every recruit presenting himself for examination.

In the use of test cards it is of the greatest advantage to have but one line exposed at a time and the letters should never be larger than the one required to pass the candidate; or, if only the regular card is available, a hole may be made in a piece of cardboard sufficient to expose one letter at a time. In this way the recruit will be unable to tell on which line he is reading. In using the test card, particularly for illiterates, it is well to insist that some answer be given, particularly as to the direction in which the letter points. Occasionally a man will get a whole line wrong, through lack of inventiveness giving the direction in each case exactly opposite to the real direction. This is very strong proof that he sees correctly. Similarly, in testing with a coin, if heads are called tails, and vice versa, every time, it is just as conclusive proof that the man sees, as if he answered correctly each time.

Much can be done by suggestion. Thus at first a man will read the large letters but later, with some sympathetic encouragement, will claim to be able to count fingers at ten feet. Still later if asked to look at your hand he will be uncertain and when told to point at your face (which even a blind man can do when guided by the voice) he will point far to one side. If then he is told "That will do. You may go," he will turn without hesitation, grasp the unfamiliar handle and open the door. While some need a kind attitude, others need a sharp command and a stern manner.

Since the object in examining a malingerer is to prove that he is not honest in his answers, careful testing at different distances will bring out discrepancies in the visual acuity too great to be accounted for in any other way than by a deliberate attempt to mislead the examiner. This method also helps one to determine whether a man is willing to do his best. The use of a stenopaic hole will greatly improve vision when the defect is solely one of refractive error. This device is helpful as a quick way to eliminate a large part of the refractive error, and if the vision does not correspondingly improve when the ophthalmoscope shows a refractive error and the absence of other defects, a strong case is at once made against the recruit. It is a short way of reaching the same results that are obtained by determining the refractive error by the use of the retinoscope, then placing the correction before the man's eyes and observing whether or not the improvement is commensurate with the usual gain. Occasionally great interest will be manifested in the records that are being made, and it is not unusual to have an applicant caught in the act of reading a card which he could not do were his vision as tested on the distant card. In the most illiterate cases it sometimes becomes necessary to rely entirely on the ophthalmoscopic examination. Only by a complete examination of the eyes, including ophthalmoscopy, can all possible causes that might result in such diminution of vision as claimed, be eliminated.

It is not always easy, sometimes impossible, to ascertain the acuteness of vision, because of lack of knowledge on the part of the recruit to understand or read letters or numerals correctly.

In this type, however, the efforts of the malingerer are manifestly crude. With some, it is evident that they have been coached, as they insist that they can see only the top line on the card, no matter at what distance it is placed. For this type the mirror test will offer means of detection, as usually they will read the same line on the card in the mirror as on the one directly in front of them, which is only one-half the distance.

The "illiterate card," a series of letter "E's" pointing in different directions, will sometimes so interest the recruit that he loses control of himself and will tell in which direction the letters point on lines much below the one he refused to see on the regular card.

At one of the camps, objects approximately the size of the letters required to be read at different distances have been used to advantage. The examiner walks 20 feet away from the patient, after having adjusted a trial frame before the eyes containing a plus 6 spherical lens before the seeing eye, and a plain glass before the "blind" eye. When 20 feet away the examiner will take a cigarette out of his pocket and ask, "Do you see these?" The answer frequently is, "I do" or "I do not smoke cigarettes." This test is given the value of about 6/30. Holding a lead pencil in one hand and a fountain pen in the other, exposing about one inch of each, he is asked, "Which do you prefer to write with?" The answer almost invariably is, "The lead pencil." This is equivalent to about 6/12. Holding a match in one hand, and asking, "Have you one? I haven't any more." The answer will be, "I have" or "I have no matches." This is recorded as 20/20.

At another camp the examiner drove very small nails into the wall about 6 feet from the floor, and when the recruits entered, they were asked to hang their hats on the nails, which could not have been seen if their vision had not been better than 6/30.

Another device to be used for the illiterates, is to have some small broken lines on the floor which correspond to the size of the letters required for 6/30 vision. A man is asked to toe the line, and if he sees enough to do so correctly, he is caught malingering at his first test.

While it is true that there is usually a peculiar attitude of malingerers which can be easily detected, great care should be exercised lest a serious error should be made and the recruit be done a great injustice. The mental attitude of one being drafted into the army is frequently such as to give him a hesitating and embarrassed manner which may appear assumed, and the applicant with a real defect that would disqualify him, is suspected of malingering. One should never be adjudged a malingerer until, by thorough examination, all possible causes that might produce the symptoms feigned have been eliminated.

In classifying malingerers, it is important to so define malingering that there can be no misunderstanding. It is one thing to include all those who feign any loss of vision, even though it is not below the required amount for exemption, and quite another matter to include only those who feign a loss of vision below the required visual standard for service. In the first instance, the total number of malingerers in a given number of examinations would be included, while in the latter case, only those whose vision is so low as to cause exemption would be included. In making reports the classification should be made distinct.

Cases of malingering are occasionally met with in which the man claims that he sees double. These must be investigated with the application of the ordinary tests as if they were genuine, with every precaution taken to guard against a serious lesion being overlooked. Terrien (*Paris Méd.*, Vol. 8, p. 462) suggests to unmask pretended diplopia, the use of two colored glasses one of which is transparent and the other ground. or opaque. The person tested having been allowed to read through the former glass with both eyes open, the latter is then substituted before the good eye. Trantas to detect simulation of monocular blindness brings black shades gradually before both pupils. This causes a black vertical band to appear in the field with a diffusion border at each edge if vision is binocular.

Pichler recommends taking of the visual field as a means of detecting simulation; and reports several cases, in one of which the field for white was smaller than the field for blue. In others the fields showed a spiral narrowing of the sort described and depicted by Hurst and Syms (*Brit. Jour. Ophthal.,* Jan., 1919, p. 17). Testing of the fields can at least be made to prove the unreliability of the patient's answers; and where impairment of the field does not correspond to any organic condition it should always be a subject for suspicion. In discussing the paper of Alger, Snell told of a man who had a normal visual field in his good eye, but claimed inability to see the test object until it was brought to the middle line, when the alleged blind eye was also left open.

Central scotoma, as Klauber points out, is not commonly understood by the laity, so that its simulation is rare. He has, however, met with three cases, one hysteric and readily cured by electricity; the other two in intelligent soldiers, one of whom had some lowering of central vision. In this case it was demonstrated by use of a prism of 10 degrees, base out, which would induce the turning in of the eye for central fixation. Stereoscopic tests may also be used for the purpose.

ASPHYXIATING, LACHRYMATORY AND VESICANT GASES IN WARFARE.

Of all the hideously inhuman cruelties introduced or reintroduced into warfare by Germanic scientific barbarism, probably none surpasses the use and effect of asphyxiant, lachrymatory and vesicant gases as weapons. The elation of the Germanic world at the evil success of their first surprise attack with this arm in the form of chlorin gas in April, 1915, was matched only by the horror the employment of this outlawed weapon provoked throughout the rest of the world, a horror which speedily gave place to bitter universal anger and finally to the justifying counter-development of such vast quantities of noxious, caustic gases that the prolongation of the war for a few months more would have seen the Teuton forces literally exterminated by the evil they themselves had set loose upon the world.

As a result of this innovation, every modern army has a division for chemical warfare attached and the idea seems to be somewhat generalized that the perpetuation of this branch of the service and the further expansion of its activities is assured, at least from the standpoint of defensive warfare.

The death rate from gassing in the American Army was about 1½ per cent., although gas was responsible for about 30 per cent. of the American casualties.

Among the various gases used as weapons are included hydrocyanic acid, sulphur dioxide and benzyl bromide, as a lachrymator. Nitric peroxide from high explosives has caused casualties, as has carbon monoxide from imperfect combustion, close quarters, burning buildings and mining operations. According to Catton (*Mil. Surg.,* July, 1919, p. 65) the gases most used have been: (a) the suffocant gases, including phosgene (COCL2), diphosgene, chlorine and chloropicrin; (b) the vesicant gas, variously called mustard gas, yperite or yellow cross and whose formula is di-chlor-ethyl-sulphide $(C2H4CL)_2S$. Latterly the two mainly used gases were phosgene and mustard gas.

Gases were first sent over in clouds from cylinders but very soon were distributed by gas shells and gas bombs. The suffocants produced their lesions by being inhaled. Mustard gas may affect by its inhalation in the finely divided state as a vapor, or by contact with it in the oily state. The oil may cling to clothing and ammunition, and hospital attendants, as far back as a base hospital, have received burns from using salvaged clothing of gassed patients 5 days after exposure. Food or water from shell holes or wells may be gassed and even after several weeks, when taken into the gastro-intestinal tract, may cause symptoms.

Suffocant gases such as phosgene are of little direct concern to the ophthalmologist, their selective action being exerted upon the lungs, where a massive edema appears, and upon the blood and the blood vessels.

Vesicant gas, such as mustard gas, however, acts upon every tissue with which it comes in contact and particularly the moist mucous surfaces. The common sites of pathology are the conjunctivæ, the skin, the upper respiratory tract and the pharynx. The skin mainly affected is over the exposed portions of the hands, that around the borders of the respirator and the sweaty places such as the axillæ, the flexure of the elbows, the groins and the perineum. Here the lesions are erythema, blisters and, sometimes, deep burns. Usually pigmentation and desquamation follow and cicatrices, if the lesions have been deep. The pharynx is usually only injected but, in severe cases, it may show ulcerations. Unlike phosgene, in the lungs mustard gas does not call out a great edema but actually burns the respiratory lining and necrosis, ulceration and sloughing occur, invariably with secondary infection.

The pathology of the lung irritants (the phosgene group) does not develop in a marked degree for some minutes after exposure and usually not for 3 to 12 hours. Accordingly, aside from a pricking sensation in the eyes, accompanied by lachrymation and moderate conjunctival injection, a slight anorexia and an unpleasant taste for tobacco smoke which follow the gas inhalation immediately, there may be no secondary symptoms until edema of the lungs, capillary obstruction, secondary oxygen deficiency and cardiac embarrassment develop.

In the severe cases with the more pronounced pathology there are two forms (a) "the blue case" where the circulatory apparatus is functioning well and there is deep cyanosis, with distended superficial veins, marked dyspnea, and a well-sustained pulse of good volume, and (b) "the gray case" where oxygen deficiency is very great and the right heart has begun to fail. Here gray pallor exists, with leaden-colored mucosæ in which the eyes share prominently. With the oxygen deficiency come temporary, and probably at times permanent, changes in the central nervous system and the autonomic system. There may be disorientation, muscular weakness, Kernig's sign, nystagmus, unequal pupils, absent abdominal reflexes, scattered sensory changes or retention of urine. The organs of taste and smell are usually disturbed. Thrombosis may occur in the vessels of the extremities and gangrene may result. Death may result from flooding of the lung from edema and from extreme concentration of the blood in the initial stages, but is not common if the first few days are survived.

According to Underhill (*Jour. A. M. A.*, Aug. 30, 1919, p. 688) the principal of the treatment of acute gas poisoning of the suffocative type consists of venesection in the period of blood dilution, which occurs in the initial stage of phosgene poisoning and of the introduction of fluid into the body by means of infusion of salt solution, the oral administration of water or even by intraperitoneal injection, during the period of blood concentration.

The pathology of mustard gas, introduced by the Germans in July, 1917, and which had come to assume a rôle of primary importance in warfare by the time of signing the armistice, develops even more slowly than phosgene and, accordingly, the soldier may be unaware for a considerable time that he has been gassed. Three to 24 hours elapse before symptoms appear, when the inflammatory reaction in the conjunctivæ may cause smarting, lachrymation, photophobia and headaches, either over the eyes or more generalized.

Derby (*Amer. Jour. Med. Soc.*, Nov., 1918) reports having found ocular lesions in about 80 per cent. of 500 cases of mustard gas poisoning. The lesions are of the nature of a chemical burn of the skin of the lids, conjunctivæ and of the corneæ in a considerable percentage. The lids are reddened, swollen and often show numerous large bullæ; they are kept tightly closed. The true ulceration observed by the French has not been noted by Derby and his co-workers. The irritation and photophobia are so intense that not infrequently resort must be had to one or two drops of cocaine and the use of a lid elevator in order to make a proper examination of the eye. Separation of the lids is often followed by a gush of tears.

In the milder cases there is but slight injection of the conjunctivæ, nearly always accompanied by slight photophobia. In the more severe cases, there is a severe injection and at times a very marked white edema and chemosis of the membranes. A secondary infection of the conjunctiva following gassing is not at all uncommon. Ciliary injection is frequent and usually represents an iridic inflammation or even an irido-cyclitis. Panophthalmitis has been reported from this source. In the more severe gas cases a careful examination nearly always discloses a certain amount of corneal involvement, varying from a slight roughening of the epithelium to a well-defined opacity, usually in the form of a band extending across the cornea in the area corresponding to the palpebral fissure.

Derby's experience is again at variance with that of the French with respect to corneal ulceration, which the latter found of common, the former of rare, occurrence. The French found that these corneal lesions stained by fluorescein; Derby found this to be true only in exceptional cases. The corneal condition tends to disappear rapidly, leaving no trace, except in cases with ulceration.

The intense photophobia, upon which so much emphasis has been placed, is explained by the corneal involvement. The neuroretinitis described by Teulières as characterized by a peculiar slate-color, has not been found by others.

The prognosis as given by Cerisé in his report to the *Société d' Ophtalmologie*, is as follows: (1) Benign cases (10 to 15 per cent. of cases): duration ten to fifteen days. (2) Medium cases (about 80 per cent. of cases): duration five or six weeeks. (3) Severe cases (3 to 5 per cent.) seen in those with marked general symptoms, who often develop bronchopneumonia.

The experience of the author places the larger proportion in the benign class. Men who are subject to blepharitis and conjunctivitis are more sensitive to gas.

Derby warns us that mustard gas burns of the eye, although tending toward spontaneous recovery, deserve careful supervision and treatment, since good treatment will shorten convalescence, make the men much more comfortable and ensure a complete recovery, except perhaps in the rarest instances. The eyes should be protected from light, but not bandaged. Patients should be kept in a moderately shaded ward. Eye shades may be improvised out of three or four thicknesses of the blue paper used for wrapping bundles in many hospitals.

In severe cases the eyes should be irrigated every three or four hours with some bland solution—normal saline, soda bicarbonate 1 per cent., or boric acid, heated to about 100° F., followed by a drop of liquid vaseline, or in the late stages, when secondary infection is common, by argyrol in a 25 per cent. solution. Castor oil theoretically is good, as mustard gas is dissolved by animal and vegetable, but not by mineral oils; practically, however, it is found to be more irritating than liquid paraffin.

Atropine should be used in all cases in which the cornea is involved, and a 1 per cent. solution instilled twice a day will usually be found to keep the pupil well dilated. As a rule, atropine may be discontinued in two or three days, but not in cases with marked corneal involvement.

Cocaine should not be used routinely, but is valuable for the first examination of the eye to relax the spasm of the lids. Dionin in 5 per cent. solution has been tried but discarded. When hyperemia of the conjunctivæ exists for a long time, a mild astringent collyrium may be used, such as ¼ to 1 per cent. zinc sulphate solution.

In many of these cases there is a persistence of the conjunctivitis with photophobia, which is increased by the slightest exposure to wind, cold and strong sunlight. Aside from the frequent use of cold compresses and mild refrigerant lotions the persistent blepharitis and eczema appear to be uninfluenced by treatment.

In a few cases, particularly those with corneal involvement vision is reduced to as low as 6/60, not capable of improvement.

Pickard (*Amer. Jour. Ophthal.,* Feb., 1919, p. 136) describes the effect upon the eyes of repeated and prolonged exposure to mustard gas in the plants where dichlorethylsulphid was manufactured.

The continual leaks have a varying effect upon the men, depending to some extent upon their susceptibility. Eyes once affected by the gas seem more prone to a second attack, and the period between attacks grows shorter, as the men are returned to work. Some cases exposed to the vapor or fumes leaking from pipes or stopcocks, would become affected with smarting of both eyes in from one to six hours. Many of the men would continue work during their shift, go to their barracks and to bed, be awakened during the night with intense pain and report to the hospital in the morning. In some cases where the gas would escape in jets as from manometers, rubber tube attachments, etc., and the face sprinkled with the chemical, the reaction would be immediate, and result in severe burns. The first cases were treated with rest in bed, cold compresses, cocain for the first day, once or twice; atropin twice daily. These remained in the hospital for from three to six weeks, depending on the severity of the reaction.

Later cocain for only one instillation, and for its immediate quieting effect was used; atropin, three times daily for its continued physiologic effect; cold compresses, boric acid flushing, iodoform powered into the eye twice daily, yellow oxid of mercury salve to the lids and a Liebreich bandage for from three to seven days, or longer as the case required. Under this plan of treatment, the stay of patients in the hospital was decreased to seven to fourteen days, with rapid amelioration of all symptoms.

It is Pickard's opinion that the deleterious effects of dichlorethylsulphid upon the eyes, can best be treated by antiphlogistic measures, ignoring to a considerable extent the chemical composition of the affecting gas. To look for a chemical antidote to neutralize its action in the eye, would more than likely lead to a substance as severe in reaction as the poison itself, whereas, by treating the inflammatory symptoms, immediate relief is obtained, insofar as pain, lachrymation, photophobia and swelling are concerned. Previous to the use of mercurial salve externally, about five per cent. of the cases developed chalazia, hordeola and small multiple abscess of the lids; but since its introduction into routine treatment there have been no such complications.

As soon as the corneal or uveal disturbance has subsided atropine should be discontinued and it is advisable to get the patient up and accustom him to the light to avoid long hospitalization.

Among the complications and sequelæ of "gassing" Mayou (*Trans. Ophthal. Soc. U. K.*, XXXVIII, p. 149) observed a case of purulent ring infiltration of the cornea following mustard gas. The soldier was blinded by the explosion of a gas shell on the nearby parapet. Six days after the explosion there was intense injection of the conjunctiva and photophobia in both eyes. The corneal lesion was the same on both sides. The surface epithelium was slightly roughened but intact over the whole of both corneæ. In the superficial layers of the cornea, about 2 mm. from the margin, was a yellow band of purulent infiltration, the margin toward the center of the cornea being sharply defined and the cornea beyond it clear. The outer margin was ill-defined and shaded off into the surrounding cornea, which was practically clear at its margin. At the end of 5 weeks' care the purulent exudation absorbed without the surface epithelium breaking down and left a fine white line beneath the corneal epithelium, which also disappeared. The photophobia and blepharospasm still were very marked at this time. Staining of the skin of the lids is a common lesion of mustard gas.

The presence of previous infection or occlusion of the lachrymal sac seems to have been largely responsible for most of the cases of marked involvement of the anterior segment of the eye and especially in the cases showing ulceration of the corneæ. The part which can be played in the formation of such ulcers, however, by the immediate use of occlusive dressings was clearly shown during the first experiences with gas. Greenwood noted a case with destruction of both corneæ from this source.

The occasional papilledema and the rare later optic atrophy which have been noted in connection with "gassing" have been explained as a possible result of the consecutive involvement of the contiguous lymphatic tracts from the cornea backwards, or as due to the severe reaction in the nose and its accessory cavities, the meninges of the optic nerve being directly affected by extension through the cribriform plate. Teulières and Valois (*Jour. Med. de Bordeaux,* Vol. 89, p. 37) note severe and protracted iritis but without synechiæ, the pupil reacting sluggishly to light and slowly to mydriasis. They state that a mild degree of neuroretinitis occurs in many cases but that this has left no permanent change save in one case where the vision remained at 3/10 in each eye after the disappearance of the retinal changes.

Kershner (*Amer. Jour. Ophthal.,* March, 1918, p. 168) reports optic atrophy in a soldier aged 23 years which followed gassing. The man was gassed twice, the second time occurring at dusk, when it was impossible to see the approach of the gas and to take preventive measures. The concentration was not great, however. The first effects noticeable were irritation of the throat with shortness of breath, not severe. The worst immediate effect was the inability to see clearly. "It seemed like a dense haze was about every object," he says. There was also nausea most of the time, with a sensation of floating, shortness of breath, and a smothering sensation which was not constant. During this stage he was taken to the dressing station, where consciousness was lost but was regained between three and four hours later in the Field Hospital, at which time a splitting headache was the most notable symptom. This was accompanied by severe pain and aching of the left arm and leg, which were very weak. It was possible to move them, only after great effort, but there was no strength in the muscular movements. Movement was accompanied by pain for the first weeks. This condition of the left side gradually and very slowly improved until he was able to discard his cane. Upon regaining consciousness, he was only able to distinguish light from darkness. This condition lasted about seven weeks, by which time objects had become discernible, and in another three weeks vision in the right eye had improved to 6/12 where it remains. The left eye failed to improve beyond the ability to discern objects.

The field of vision for the right eye, as indicated on the accompanying chart, revealed contraction for form as well as for colors and a very slight enlargement of the "blind spot." It was impossible to obtain any sort of field in the left eye. Both discs were pale, the atrophic change being more marked in the left than in the right. von Szily depicts (Fig. 309, p. 444, *Atlas der Kriegsaugenheilkunde*) a case of bilateral postneuritic atrophy from "gassing." Ratnakar (*Lancet,* March 15, 1919) submits the history of a man who said that he could not see for two days after having been gassed, but that after this time he could gradually open his eyes and could see fairly well. About a fortnight after he was gassed his attention was drawn to the oscillations of his eyeballs, as the patient described the condition, by the medical man at the military hospital to which he was removed. Patient was a microphotographer at one of the largest hospitals in London before he joined up. His vision was excellent, and he had no nystagmus then; there is no reason to doubt his statement consider-

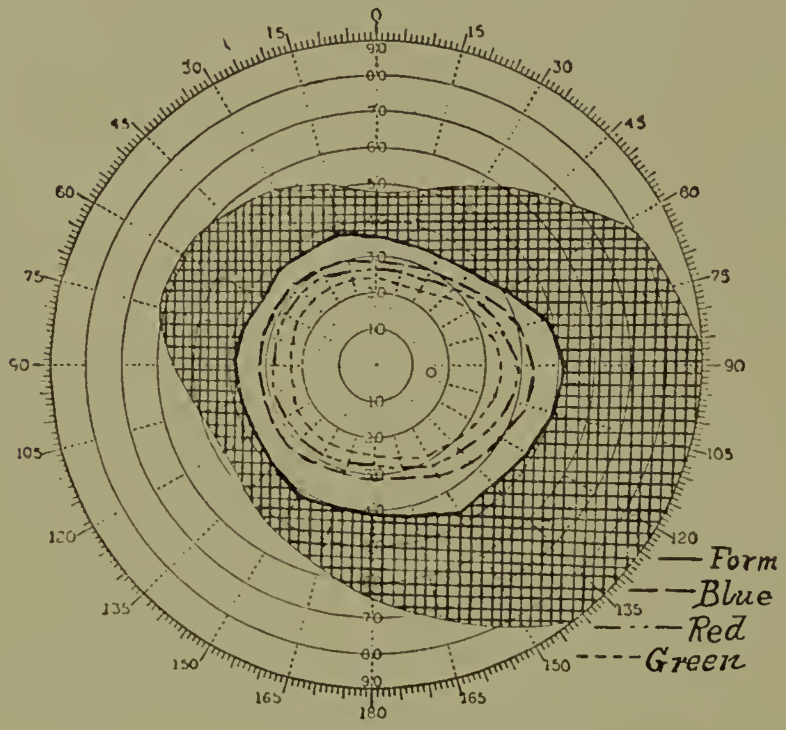


FIG. 1.

Fig. 1.
Field of Vision for Right Eye in Case of Gassing, Showing Contraction for Both Form and Color Fields. (Kershner.)

ing his work before and after joining the Army. On examination the condition was as follows: Lateral nystagmus; pupils regular, active, medium; movement of the eyeballs, conjunctiva, cornea, and media normal. The fundi were also normal. Nystagmus constantly present, but more marked on extreme outward and inward movements. Vision in both eyes 6/18 partly, not improved by glasses. Letters run into one another. Retinoscopy after a mydriatic: R. and L. + 1 sph. Fields of vision and color perception normal; no central scotoma. The patient returned to the hospital for re-examination after three months as directed, and the condition was found to be practically the same.

Several weeks or months after gassing residual symptoms may exist still referable to gassing and including chronic bronchitis, functional aphonia, persistent vomiting, photophobia, blepharitis and blepharospasm. The functional forms of these conditions have undoubtedly had an initial local irritation as their origin which has led, not infrequently, to mental fixation upon these particular symptoms and the persistence of psychoneurotic complexes erected on the foundation of the minor local conditions. These are immediately relievable by fitting psychiatric persuasion. Hurst (*Seale-Hayne Neurol. Studies,* v. 1, p. 71) and Hurst and Ripman, detail a case of hysterical left strabismus and amblyopia following gassing and discuss the relation of gassing and the hysterical ocular symptoms which cluster about the focal point of conjunctivitis.

NIGHT-BLINDNESS (HESPERANOPIA).

The terms hesperanopia and hesperanope proposed for this condition and for the afflicted by Terson (*Arch. d'Ophtal.,* Jan.-Feb., 1919) are highly acceptable solutions of the definitive haze cast about the subject by the older and incorrect terms hemeralopia, nyctalopia and their like. The word hesperanopia, derived from the Greek word for "dusk" and "a" privative, is both unequivocal and euphonic and deserves general recognition.

The interest aroused in this subject, by outbreaks of what appeared to be epidemics of night-blindness among soldiers, has evolved an extensive literature dating back to the earliest months of the war. The first conception of these group defects was that they were the product of some form of vitamin deficiency in the food or that they represented psychogenous functional changes or actual malingering. The correlation of the various studies, however, shows that a distinction must be made between those who complained of poor nocturnal vision prior to the war and those who developed the symptom as a result of the conditions of warfare. In the first group come the cases of true hesperanopia, including men with choroido-retinal lesions and some rare cases of retinitis pigmentosa, choroiditis, congenital affections of the neuro-retinal system and of congenital night-blindness, the last probably physiological. The second group embraces the false or pseudo-hesperanopic conditions arising from uncorrected or badly corrected refractive conditions, especially myopia, corneal lesions and defects of the ocular media, loss of blood, faulty nutrition, emaciation, and the disturbances of vision seen in states of nervous exhaustion, arterio-sclerosis, and alcohol and tobacco poisoning. Any of these factors may be operative alone or in combination. In the acute form, sudden light dazzling often precipitates the attack, possibly from rapid exhaustion of the visual purple which had been maintained in functioning amount only with difficulty even under normal conditions. In many cases the defect was first noted during the first dark nights on duty. Danis (Abstr. *Amer. Jour. Ophthal.*, Aug. 19, 1919, p. 155) who found 203 cases of this form of complaint among 2,700 eye patients, believes the condition to be the effect of disturbance of the choriocapillary circulation which interferes with retinal adaptation. Birch-Hirschfeld (*Arch. Ophthal.*, Nov., 1917, p. 600) found that of 155 soldiers who complained of hesperanopia the condition had been recognized to greater or less extent before the war in 120, usually in their early youth. Of the 35 who developed the condition during the war 11 had been wounded and had lost considerable blood, 5 had suffered from intestinal troubles, 3 had been exposed to the dazzling effect of strong lights and 1 had been poisoned by optochin. The cases were always sporadic and their average age was 34½ years. The nutritive condition of about half these men was poor. Fifty-four of the cases were emmetropic, 17 hyperopic, 14 astigmatic and 70 myopic, a myopia of more than 6 D. existing in 31 of the last group. Central vision was normal in 69, fair in 67 and bad in 19. The ophthalmoscope showed a normal eye in 73, deficit of fundal pigmentation in 34 and individual pigment anomalies in 41. The visual field was contracted with reduced illumination, especially for blue in 121, moderately for white and blue in bright daylight in 36, and to a high degree in 30.

The central and peripheral perception of blue was almost regularly disturbed in reduced illumination. Special care was given to the determination of the stimulative threshold and the adaptation, which revealed 3 kinds of the disturbance. 1. Elevation of the threshold with good adaptation in 33. 2. Flat curve of adaptation with a slightly raised threshold in 17. 3. Elevation of the threshold in greatly diminished adaptation in 103. The third type includes particularly the cases with marked disturbance in vision, visual field, and color sense, and presenting retinal changes. Between the 3 varieties are transition forms, and a case may pass from one type to another. Of 54 cases observed for several weeks, only 10 showed an essential improvement. He does not consider the patients fit for military service if after ½ hour's adaptation to dark the sensitiveness is less than ¼ of normal. Only in rare and special cases is the injury to be ascribed to the service. Treatment consists of correction of refractive errors, improvement of the general condition, and protection against dazzling. He thinks night blindness to be a trouble not dependent on any one cause, and that the term war hemeralopia is not suitable. Various factors may take part in its etiology, some general, some local. Among these may be named hereditary influences, which were present in 1/3 of the cases; myopic changes in the retina or choroid; faulty nutrition, lack of vitamines; debility caused by intestinal or liver troubles or by loss of blood; poisoning by optochin, quinine, or perhaps alcohol. Dazzling may perhaps be a factor. Neurasthenic symptoms are not rare, yet it is a mistake to consider the trouble a variety of neurasthenia. The entire symptom complex is not indicative of a psychogenous cause, but points to an organic disturbance of the apparatus connected with the increase of sensibility in the dark.

McKee (*loc. cit.*) believes, however, that there is little doubt but that many soldiers have heard a chum complain of night-blindness with the desired results, and have then gone and done likewise. A clever malingerer finds it an easy complaint to simulate, and the simulation is hard to detect.

Jess (*Arch. Ophthal.*, Nov., 1917, p. 598) finds simulation cannot be determined at the front owing to the difficulty of reliable investigations of the dark adaptation at the advanced eye stations. He recommends, therefore, a careful examination of the visual fields, as characteristic disturbances are almost constant in true hesperanopia. In order to recognize beginning contractions of the blue-yellow limits as compared with the red-green, it is necessary to note with special care the limit for yellow, as a contraction of the yellow field may be found when one for blue cannot be made out. Of 61 soldiers of all arms, who were said to be night-blind, 35 showed typical disturbances of the visual field, which confirmed the diagnosis of hesperanopia. Of the remaining 26, 6 were so-called dioptric hesperanopes, 18 showed no disturbance of adaptation on examination with a photoptometer, and only 2 had a distinct disturbance of adaptation with no anomalies of the visual field. A number of pictures showed the typical displacements of the color boundaries, their enlargement with improvement of the hesperanopia, their greater contraction as the latter became worse, as well as paracentral defects in the form of ring scotomata, of which 7 were observed resembling the peripheral scotoma produced by dazzling. Careful investigation of the histories and prolonged observation established the fact that only 8 of these cases originated in the field, caused perhaps by nutritive disturbances and weariness, while all of the others were congenital, had developed before the war, or were due to local disease.

The Paris letter in the *Jour. A. M. A.*, Sept. 9, 1916, p. 827, states that the frequence of hesperanopia, extremely low in time of peace (1 in 12,000 in France, according to Walter), undergoes an augmentation in wartime. At Verdun, Dr. Bourdier found 8.78 per cent. in ocular examinations during the winter of 1914-1915. At the same period, many cases of the condition occurred in the German army. More recently, Vejers has observed it in proportion of 10.2 per cent. This high figure depends on many causes, some peculiar to the late war, which presents conditions different from those which have prevailed, in the past, such, for example, as the higher mean age of the combatants. The hesperanopia in this war as observed by the French differs from that which has been described in previous wars in two respects: In the first place, there has been no epidemic, and, the revictualing of the army being satisfactory, there have been no crises of this character due to privation and physiologic misery. By reason of selection, symptomatic hesperanopia is rarely found more in military than in civil life. In most cases it seems related to some vice of refraction and principally to myopia. The condition was observed among volunteers in the early months of the war, among officers of the regular army and medical officers, and because of these facts and others contained in the reports of the commanding officers and because of the isolated character of each case, it is evident that, in the late war, hesperanopia was a symptom rarely invoked by malingerers. Except for those cases traceable to general diseases (of liver and kidneys) or to ocular fatigue or disease, there seems to be no satisfactory treatment for the condition.

With regard to military employment of patients suffering from hesperanopia, the requirements of the command must be taken into consideration, and it is necessary to point out to commanding officers, whose complaints have been occasionally rather pointed, that the condition appears to be scarcely if at all curable; that those affected by it should be distributed at the front among the day-working parties.

(In examining men for their aptitude for different special services, the experience of the war has shown that in the future it will be necessary to control not only the visual acuity and the visual field, but also the power of adaptation to varying degrees of illumination. This is especially true of candidates for the posts of aviator and automobilist.)

In an extended review of many clinical studies of this subject which appeared in the *Amer. Jour. Ophthal.,* April, 1919, pp. 154-159 Weekers (*Arch. d'Ophtal.,* Vol. 36, p. 203) considers the hesperanopia acquired during the war as the effect of overwork. In the diagnosis not only the retinal adaptation as such must be considered but also the adaptation curve. Before the war using the adaptometer of Nagel, he found reduced retinal adaptation in persons without any complaint as to their sight. In civil life hesperanopia is found under similar conditions, especially in the coal mines, among the laborers of St. Gothard tunnel. In these cases he found either retardation or insufficiency of the adaptation. The cause for these cases must be looked for in the overwork and in nervous exhaustion, and for this reason hesperanopia is found mostly among the infantry who have long marches carrying heavy equipment. Its incidence diminished in the Belgian army when conditions became more favorable as compared with the beginning of the war. He considers the condition due to insufficiency in the retinal adaptation from exhaustion, a condition to be separated from the hesperanopia of malnutrition. Fatigue changes the function of the endocrin glands and the visual purple and the adaptation might be influenced by them; relation of the suprerenals to the pigment is well known.

Dor (*Clin. Ophtal.,* Vol. 22, p. 610 and Vol. 23, p. 83) observed three cases of traumatic hesperanopia and gives the details of one. A soldier who had been buried by the collapse of his shelter was found unconscious and with a fractured skull and thigh. When consciousness was restored, after trepanation, he found himself blind. Vision gradually returned by the end of a month but marked hesperanopia remained and persisted when seen ten months later, when vision was 2/3, the fundi normal and the fields not contracted. Dor assumes that the reflex migration of the retinal pigment can be interrupted by intracranial changes, the reflex probably having its seat in certain fibers of the optic nerve, in some part of their course, presumably in the geniculate body. Such an explanation would account for hesperanopia with unaltered retinal anatomy. The counterpart to this hesperanopia, in which the retinal pigment does not leave the region of the rods when the light becomes faint, are those cases generally mistaken for photophobia, but which are true cases of nyctalopia. Here the retinal pigment remains in the position occupied during darkness and does not advance around the rods during light. Dor states that cerebral contusion can cause nyctalopia as well as hesperanopia and believes that the term photophobia should be reserved for those cases of light-sensitiveness which are independent of pigment migration, such as inflammation. Koeppe (*Münch. Med. Woch.*, Apr. 9, 1918) found an examination with a Nernst slit lamp and the corneal microscope that the corneæ and lenses were uniformly reduced in transparency. The association of these conditions with the congenital weakness of the retinal light-perceiving elements is thought to create a hesperanopic predisposition which leads to a frank manifestation of the characteristic symptoms after exposure, exhaustion and malnutrition. This lessened transparency of the cornea and lens may be considered an objective method of proving the claim of night-blindness in doubtful cases. Stenitzer and Schroeder (*Hospitalstidende*, Vol. 61, p. 481) found no especial influence of cooked liver on the hesperanopia. Jess (*Klin. M. f. Augh.*, Vol. 61, p. 345) repeatedly observed hesperanopic complaints in patients with perforating injury of the eye or with phthisis bulbi. He believes that there is some causative relation between the disturbance of adaptation of the hitherto healthy eye and the perforating injury of the other eye, that the hesperanopia is a symptom of sympathetic irritation or ophthalmia. The curve of adaptation of one of his patients showed marked lowering while the curve of the same patient nineteen days after the enucleation appeared entirely normal. The field in the same case before the enucleation was moderately constricted and the color limits reversed, while after the enucleation field limits and relation of colors were perfectly normal. He mentions ten other similar cases. He also demonstrates the fields of cases of acquired hesperanopia which all, after the disturbance of adaptation has disappeared, show the peculiarity that the yellow field limits become normal only after the blue limits have reached the normal extent, a condition considered of diagnostic importance by him since 1916.

Hillemanns asserts that a hesperanopia of war has no existence. Most cases of disturbed light sense are found in myopes because of the damage of the pigment epithelium and of the rods by the myopic stretching; ophthalmoscopic changes are not necessary. It is doubtful whether disturbed light sense occurs in high hyperopia and astigmatism; in these cases the effect of the dilated pupil is of greater importance. Opacities of the media will reduce vision when the pupil becomes wide; dioptric hesperanopia. In the examination the central visual acuity must be separated from the peripheral light sense. Many patients with chorio-retinal disturbance show disproportionate reduction of vision with reduced illumination. The test object during reduced illumination falls also on the extrafoveal rod-containing region. As the simplest and most practical military method of examination of adaptation, he therefore recommends examination of the visual acuity with reduced illumination, such as in a poorly lighted room or with the use of smoked glasses because it is of greatest importance for the function of the eye in the dark how its central direct vision is influenced by the reduced illumination.

Of the 700 cases of hesperanopia observed in the Servian army, Nechitch could follow 528 for a longer period. Four forms of hesperanopia exist, according to him: It is either symptomatic, as in chorio-retinitis and retinitis pigmentosa, or idiopathic and without any perceptible fundus lesion. In daylight symptomatic hesperanopia has reduced visual acuity, the idiopathic form, normal vision. Patients with errors of refraction or corneal opacities have no real hesperanopia, theirs is a pseudohesperanopia. Congenital hesperanopia is seen in individuals with weak adaptation but more or less normal vision. The hesperanopia of the World War is an idiopathic hesperanopia caused by defective nutrition. The sensitiveness of the retina in this affection is not the same over its whole extent, thus producing five types of idiopathic hesperanopia: (a) total; (b) with peripheral vision; (c) with eccentric vision; (d) with relative scotoma; (e) with annular scotoma. It is a binocular affection and it may change its type during treatment. Improvement, even spontaneous cures, are not rare, but not lasting. In this disease the functions of the retina are lowered and the photochemic changes are hindered through the defective nutrition of the retina. Treatment must be in hospitals to improve the general condition of the patient. Cod liver oil, subconjunctival saline injections, iron and arsenic tonic. Relapses occur when the general condition has not sufficiently improved. No ill consequences have followed long duration of the disease.

Best (*Zeit. f. Biologie*, Vol. 68, p. 141) maintains that only by the separate examination of adaptation with red free and long waved light can a clear conception of night-blindness be gained. His adaptometer, consisting of discs covered with radioactive substances, is devised for this purpose. During dark adaptation the increase of sensitiveness for light from radioactive substance ceases in the rodfree area but continues in the periphery for thirty to forty minutes longer. For long waved light such contrast between macula and periphery exists only in a minor degree. From this must be concluded the presence of at least two photochemical processes in the retina. He detected simulation of night-blindness in two patients because they claimed not only to see light from radioactive substances but even the long waved red. In doubtful cases the behavior of the patient during reduced illumination is to be watched by the examiner wearing dark glasses. The end value of dark adaptation varies greatly for the periphery, less for the rod-free area. The disturbance of adaptation may be uniform through the whole extent of the spectrum, the whole process of dark adaptation is disturbed; or the disturbance is primarily in the accumulation of visual purple or of a recipient substance for long waves; or, finally, the disturbance concerns not only the accumulation of the receptive substance but also the corresponding color sensation. The German army had no epidemic and no war hesperanopia. Sixty-six per cent. of Best's cases were caused by errors of refraction. Ten per cent. had no lowered end value of dark adaptation; in these cases the retardation is a very fine indicator. Objective changes such as pigmentary degeneration, choroiditis, optic atrophy and corneal opacities were found rarely. The fundus changes described by Augstein were not characteristic. Functional neuroses were present in 8 per cent. Malnutrition, nephritis, digestive disturbance, in 2 per cent. He had not seen the peripapillary edema of Jess. Dazzling as the cause was noted in 2 per cent. Overwork as the cause was negligible. Most of the patients knew of their defect before the war. A hesperanopia acquired during the war cannot be defined but is very rare. Tobacco and alcohol produce a central scotoma but leave the dark adaptation of the periphery intact and cause, therefore, no night-blindness. Retinal and choroidal affections will sooner lead to disturbed adaptation than optic nerve affections. In all cases of retrobulbar neuritis dark adaptation was less disturbed than the color field. In three cases of color blindness adaptation in long-wave light was not nearly so diminished as in light from radioactive substances. For night-blindness acquired during the war 5 per cent. of the earning capacity should be allowed as compensation.

Utilizing Nagel's adaptometer and Foerster's photometer, Huebner (Graefe's *Arch. f. Ophth.*, Vol. 93, p. 360) studied the course of adaptation of normal soldiers and of those complaining of poor vision at night. The diagnosis of hesperanopia can only be made, he says, when disturbance of adaptation has been proven positively. Persons with an inferior nervous system may develop disturbance of adaptation through stress of war. Hesperanopia as a symptom of other eye affections exists. He has observed no hesperanopia attributable to defective nutrition. Patients who, in spite of normal adaptation, complain of poor vision at night are not true hesperanopes; their complaints are explained by low vision even in the day time and by lack of experience.

Referring to the facts established by Koeppe and himself with the Nernst slit lamp, that the lens is less transparent in cases of congenital hesperanopia, Schieck (*Klin. M. f. Augh.,* Vol. 60, p. 843) suggests that in the soldier's papers should be entered within which limits he might be employed on account of night-blindness.

Polock observed an inversion of the phenomenon of Purkinje in five cases of congenital hesperanopia. He used a flat screen, half of which was red, and the other portion blue, and had it so arranged in a dark room that varying intensities of daylight could be thrown on both colors equally. He found in all of his cases that as the light intensity was diminished the blue was the first to disappear, and when tested from obscurity the red was the first to appear, and increased in intensity as the light was increased.

In certain cases of hesperanopia both colors appear and disappear at the same time and an inversion of this phenomenon is not present.

For the determination of the function of the eye in the dark Boehmig (Abstr. *Klin. M. f. Augh.,* Vol. 60, p. 409) experimented with the apparatus of Cramer. This consists of a Landolt ring (D-25) coated with radioactive substance and mounted on a black board, and is to be viewed in varying distances and varying dark adaptation. Men able to recognize the break in the ring at 3 meters after forty-five minutes dark adaptation, are militarily fit for all purposes; those seeing the break at 1 meter and below are to be considered night-blind and are unfit for duty at the front. Between these groups are the men whose form of military service has to be decided upon according to the degree of faulty adaptation. Goldman (*Wien. Klin. Woch.,* Vol. 43, p. 1127) found hesperanopia to be one of the manifestations of a complex cerebral symptom following traumatism and infections which he has observed in a number of cases. He localizes the disturbance in the optic thalamus. The fundi were always negative in his cases, in some of which both hesperanopia and the cerebral symptoms disappeared after several weeks. Such cases are due neither to simulation nor to neurasthenia.

Meyer (*Klin. M. f. Augh.*, Vol. 60, p. 712) examined three hundred cases of hesperanopia, and concluded that the illumination rate for blue especially was established, and that there is no specified color limit for it, but the color gradually becomes gray as the limit of the field of vision is approached.

He further demonstrates an undersensibility for red in nearly all cases. He believes that there is no such disease as the so-called "war hesperanopia,'' and only in fourteen cases the hesperanopia could not be explained by anatomic findings or history. In all other cases the condition was accounted for by the army rations, combined with the strain of night duty in the field or a general neurasthenic predisposition.

High grade hesperanopia interferes considerably with efficiency both at home or in service, and while the middle or low grades would not disqualify from garrison duty, a high grade hesperanopia ought to disqualify from service.

The present status of hesperanopia is further discussed in papers by Junius (*Zeit. f. Augh.*, *Vol.* 36, p. 49), Aubaret (*Lancet*, June 2, 1917, p. 853), Löhlein (*Wien. Med. Woch.*, 1916, p. 1242), Mosso (*Gior. Med. Mil.*, Vol. 65, p. 401), Hüft (*Wien. Klin. Woch.*, 1918, p. 939), Krebs (*ibid*, p. 857) and Jackson (*Med. Record*, Vol. 94, p. 900).

OPHTHALMOLOGY AND MILITARY MEDICINE.

The ramifications of ophthalmic practice in military medicine are, if anything, wider and more varied than those of civilian practice, the conditions of overcrowding which prevail in cantonments, and in modern active military service and the unavoidable gross hygienic faults contingent upon active warfare at the front, exposing vast bodies of men to epidemics of every conceivable sort, in many of which the direct or remote ocular manifestations are of importance or of interest.

A large proportion of the ocular diseases seen by the ophthalmologist in military service are those in which the strain and necessary filth of hard campaigning, with insufficient food and exposure to inclement weather, have led to the same ocular diseases and recrudescences of old general and ocular diseases which might be expected to result from similar strain or exposure in civil life. The conditions most frequently noted are chronic and acute conjunctivitis in all its clinical and bacterial forms, fresh and recurrent cases of dendritic, eczematous and parenchymatous keratitis, trachoma, serpent ulcer, rheumatic, luetic and gonorrheal iritis, the last usually associated with old and unhealed urethritis, and the important group of ocular signs and symptoms characteristic of general toxic diseases.

Conjunctivitis, the reactive response of the eye to exposure to sun, wind, dust, infection, cold, gas, enforced uncleanliness of battle and the unnatural strain put upon even normal eyes, is obviously the most common of medical conditions. In Saint-Martin's experience 88 per cent. of the medical eye conditions were acute and chronic conjunctivitis. No great epidemic of conjunctivitis has appeared, however, in spite of the unprecedented numbers of men engaged in this greatest of wars, a matter of historical contrast when the situation of Hannibal's army during their winter camp in Italy, the prevalence of ophthalmia in Europe during the Napoleonic wars and its frequency in the American Civil war are recalled. Small localized epidemics have occurred, like that reported by Kershner at Camp Sherman, where during the last three months of 1917 over 1200 men were affected with acute catarrhal inflammation of the eyes. The pneumococcus was the organism most frequently found, with Koch-Weeks and Morax-Axenfeld infections in small number and rare gonorrheal involvement. Xerosis bacilli and various types of staphylococci were also held responsible in a few cases but the striking feature was the large percentage of cases showing no organism.

The causes considered responsible for this epidemic are crowded condition of men and their close association either at work, at play or at rest; that it began after cold weather had set in, and to make the most of the artificial heat, ventilation was defective in these rapidly-constructed semi-permanent quarters. As regards cases of conjunctivitis in which no bacteria were found, the question arises as to whether it could be mechanical and due to "cold," dust, smoke and the crowded proximity of the men.

The factor "cold" includes wind with a low temperature, and low external temperature alternating with the humid warm atmosphere of the artificially heated barracks. There were two sources of dust—the dust in the air from sweeping and the tramping on the floors, and dust from the roads aided by the smoking of the men, and gas from stoves.

Relatively few cases of gonorrheal conjunctivitis appeared in the U. S. Army owing, probably, to the high moral tone of its mission in the war, to the care taken to educate the men as to the dangers of gonorrheal infections in general and to the promptness with which urethral infections were placed under vigorous medical care. Gassing was responsible for much of the conjunctivitis and this form of inflammation was often highly resistant to treatment. The importance of prompt and skilled care in cases of purulent conjunctivitis, especially of the gonorrheal type, is shown by Cirincione's statement (*Policlinico*, June 10, 1917, p. 757) that in his rounds as an inspector in the Italian Army he encountered 200 cases of loss of one or both eyes due to purulent conjunctivitis which had been untreated or poorly treated until too late.

Magitot (*Ann. d'Ocul.*, cliii, 6) has seen a large number of soldiers with kerato-conjunctivitis accompanied by nasal lesions. The nasal lesions in one hundred such cases were acute rhinitis 30 per cent.; atrophic rhinitis 5 per cent.; tertiary syphilis in nose 7 per cent.; maxillary or frontal sinusitis 13 per cent.; nasal polypi 2 per cent.; hypertrophy of lower turbinates 15 per cent. and septal deviations 25 per cent. In cases of this sort the conjunctiva is congested but without muco-purulent secretion, the cornea is slightly hazy and a few small and shallow ulcers appear at the limbus. The process keeps pace with the progress of the intranasal situation and a permanent cure is produced only by the correction of the basic nasal disorder.

Among the interesting and uncommon forms of conjunctivitis that which occurs as a metastatic complication in bacillary dysentery has been noted by many observers. Cosse and Delord (*Ann. d'Ocul.*, cliv, 1) report twelve such cases. In four the conjunctivitis, which appeared on the fifth to the twelfth day after the onset of the dysentery was of a mild type and cleared in from six to seven days. In the remaining cases, however, the conjunctivitis appeared simultaneously with a polyarthritis of the knee, elbow, tibio-tarsal and shoulder joints. In one case the conjunctivitis preceded the dysentery which was more severe in this entire group having arthritic complications. Both eyes were affected at the outset, the inflammation being limited to the lower lid in the milder cases and being more marked in the lower lid in the severer form. As the scanty secretion lacks pathogenic bacteria and the clinical evolution of these cases is entirely different from that occurring in bacterial infections, the conjunctival reaction is evidently of toxic rather than of bacterial origin. One patient exhibited an iritis and a marginal keratitis.

Morax saw one case in an epidemic affecting 250 men in the barracks. The conjunctival disturbance occurred at the end of the second week of the disease, and on the thirty-fifth day became complicated by a relapsing iritis in the right eye. He agrees with Feissinger and Leroy, who consider the articulo-ocular syndrome as analogous to the blennorrheic syndrome.

McKee (*loc. cit.*) states that "conjunctivitis has been associated with dysentery often enough to excite notice "and relates further that he himself developed severe conjunctivitis during convalescence from dysentery, the conjunctivitis being prodromal to an acute polyarthritis.

Maxwell and Kiep observed six cases of iritis or cyclitis in patients infected with bacillus dysenteriæ in the Mediterranean region, in four of them with arthritis. They concluded: (1) Patients suffering from an infection by bacillus dysenteriæ (Shiga) may occasionally develop anterior uveitis as a result of this infection, as pointed out by Morax.

(2) This ocular affection may, or may not, be accompanied by articular manifestations. (3) The ocular affections would appear to occur most frequently about one month after the first signs of involvement of the bowel, but may occur as early as the twelfth day. (4) The articular-ocular syndrome corresponds exactly to that occurring in another affection of a mucous tract, viz. gonorrhea, as pointed out by Garrod.

Early in the war it was evident that the unhindered spread of tens of thousands of refugees from Galicia and from those portions of Russia, Austria, the Balkans, Arabia and Turkey which have been the immemorial hotbeds of trachoma, would leave its baneful wake among the populations through and into which the afflicted subjects filtered. That this actually occurred is told by Koenigstein (*Wien. Med. Woch.,* March 16 and 23, 1918) who states that trachoma extended over all Austria, being especially frequent in Galicia. The painstaking routine examination, segregation and treatment of the great labor companies introduced into France from China and Egypt not only prevented the spread of the disease to the soldier and civilian populations but led to the control or cure of the disorder among the importees. Nineteen per cent. of the Egyptians and 9 per cent. of the Chinese had active trachoma. These laborers were divided into groups with clean eyes, those with conjunctivitis, and the trachomatous. They were formed into companies of 500 each and the infected cases sent, if possible, into an area where they could work under the supervision of a medical officer experienced in ophthalmic work. All the clean companies were treated routinely with zinc drops and the universal drop treatment was carried out daily among the infected companies, the men forming in squatting rows and drawing down their lower lids while they looked upward. A native orderly passed rapidly along and dropped two drops of the following solution into each eye: Acid boric gr. 10, Zn. sulph. gr. 2; Aquæ to one fluid ounce. In this way a whole company could be treated in 20 minutes. The object of this treatment was to keep the men fit and to prevent the spread, rather than to cure the condition and as a result the sickness-hours among the infected companies did not exceed those of the clean. On no account was a man transferred from an infected to a clean company.

Zimmer met with 27 per cent. of occurrence of trachoma in a ten months' service and found that 50 per cent. of the Russian prisoners whom he cared for in Germany were infected. He noted rapid improvement through the routine employment of 10 per cent. copper sulphate in glycerine. von Hoor (Abstr. *Amer Jour. Ophthal.,* March, 1918, p. 38) found in Austria that a considerable number of trachoma patients in and near the age of liability to military service, were skillful in escaping all attempts at supervision and treatment. This practice was overcome by the military authorities, both in the interests of the army and of general prophylaxis, by refusing to accept trachoma as excluding the patient from military service, and also by placing all trachoma patients who were liable to military service in military institutions, under the care of special physicians, until they were completely cured, after which they were sent for military service or were dismissed, according to the age at which the cure was effected. The average length of treatment was four months, and about 80 per cent. of the patients were cured within the period of liability to military service. During the service age the trachoma patients were given regular military training at the garrison hospitals.

It has become general opinion that the trachomatous men should not be rejected but should, instead, be segregated and treated until the disease is cured, at which point a reexamination determines the degree of vision and its practicability for military service.

Nephritis in the soldier and its ocular manifestations. Acute nephritis was not important in warfare until the present time, with the exception of the American Civil war, when 14,000 cases were recorded. In 1915 according to Fritz (*Jour. A. M. A.,* July 19, 1919, p. 168) it appeared among the combatant troops of both sides and reached a point among the British in 1917-1918 where it represented about 5 per cent. of all medical casualties sent from the line.

Kayser (*Berl. Klin. Woch.,* Sept. 18, 1916, p. 1043) reports the development of herpes over the whole lower part of the face in a case of war nephritis convalescent from uremia. One eye became inflamed and papillitis and blindness in this eye ensued. The other eye was not affected and complete renal recovery ensued. Evans (*Trans. Ophthal. Soc. U. K.,* Vol. XXXVII, p. 238) examined the fundi of 100 cases which had been referred by competent internists who had made a diagnosis of war nephritis.

Normal fundi were found in 43, while changes were noted in the fundi in 57 per cent., the fundus changes being involvement of the optic nerve and retina in 39 cases and of the choroid in 34. These changes are slight and must be looked for with a dilated pupil and by direct retinoscopy lest they be overlooked. Many of the lesions were doubtfully pathological both in the retina and choroid and in only one case, a man of 56, evidently affected with chronic Bright's, was the classical appearance of the hemorrhagic neuro-retinitis of albuminuria observed.

The process in both retina and choroid appears to be of a low inflammatory nature, giving rise to slight edema of the disc and adjacent retina and occasionally to a few fine retinal deposits. Depigmentary changes are set up in the hexagonal epithelium and choroid either with or without slight and fine pigmentary deposits. Occasionally more acute but more localized foci show as fine areolar spots with very limited pigmentary accumulations at their edges. The more definitely punched out white spots with markedly pigmented rims have been ascribed to lues. The slaty patches are suggestive of small choroidal hemorrhages, but this is highly doubtful as no intermediary stage of these has ever been noted. It is possible that they may have been due to small choroidal thromboses. Syphilis and sepsis, particularly oral sepsis, have been suggested as possible causes but no support is given these suggestions by the condition of the fundi. The changes, in general, point to a toxic or infective origin and resemble the changes seen in advanced age. The nephritis is of the type which follows scarlatina and, as desquamation of the skin and comparable dequamation of the renal epithelium are characteristic of many of these cases, it is likely that the changes are produced by infecting agents and their toxic products. While on duty at Malta, Kirk (*Brit. Med. Jour.*, Jan. 5, 1918; abstr. *Amer. Jour. Ophthal.*, Apr., 1918, p. 275) had the opportunity of examining about 80 cases of war nephritis, all from the Macedonian front.

These were chiefly young active soldiers between 20 and 30 who had suffered fairly severe exposure and strain. Nearly all the cases presented the disease in a severely acute form, and on their admission were mostly seriously ill; at that time there was found invariably marked retinal congestion with large pulsating veins but no signs of exudation or nerve involvement. Some weeks later nerve swelling and patches of retinal exudate were found in some; this led to re-examination of all of the cases about three months from the onset of their illness, and the writer was then able to classify them as follows:

Group A. 21 cases, all convalescent and without symptoms except slight anemia and debility and no albumin in the urine, except a slight trace in a few. Retinal changes appeared in only four instances, and such changes were slight, a few small spots of exudation, a small punctate hemorrhage, a slight haziness of the disc edges, or a little edema along the course of the veins.

Group B, a series of 20 cases, which had not progressed as well as the others, showed albumin in small amount, and often dyspnea and slight edema; 8 of these showed minor retinal changes with small spots of exudate.

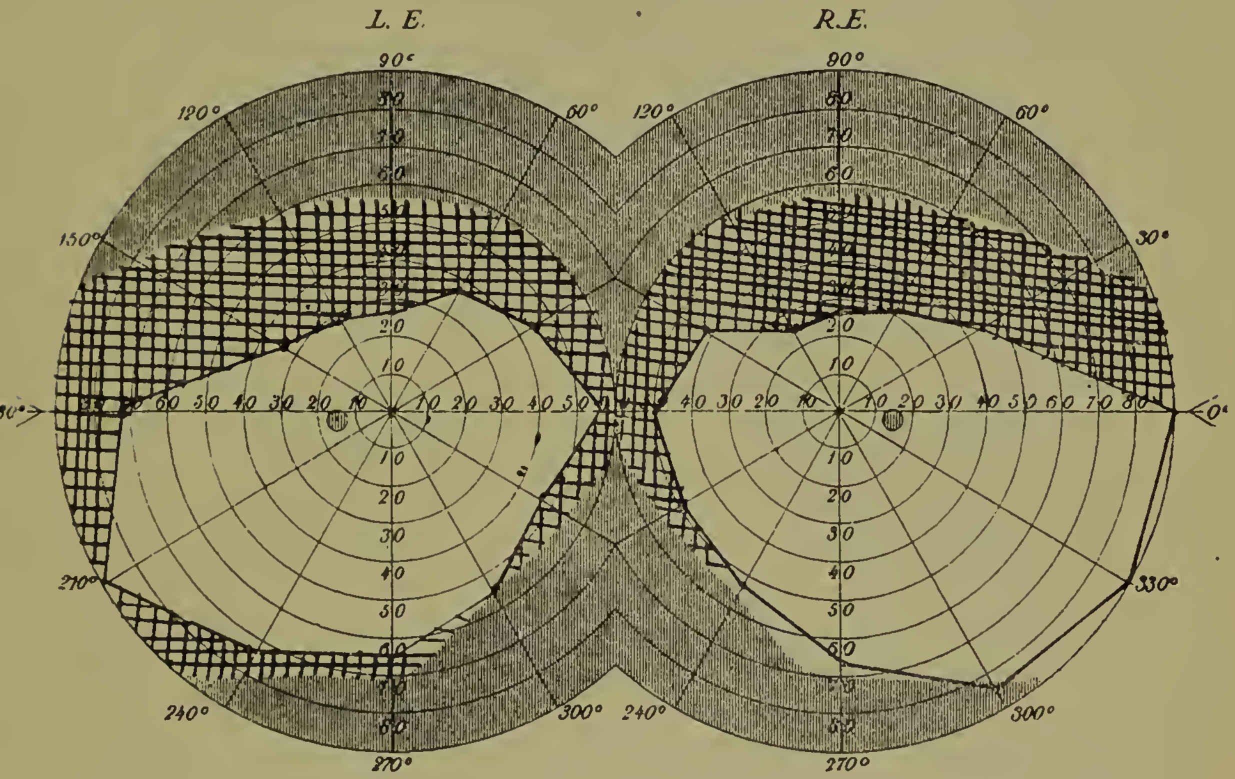
Group C, 13 in number, were severe cases in which the disease was still marked; these were suffering from marked general symptoms, severe edema, a large quantity of albumin in the urine and sometimes blood; 4 of these showed very definite retinal changes and 4 changes of slighter nature.

As far as could be ascertained, there were no signs of any other complicating disease, with the exception that several cases showed malarial infection. In none was there any history of previous kidney attacks. In 9 of the cases presenting the more severe retinal changes a Wassermann test was done, and in all of the 9 the result was negative.

Regarding the fundus changes, it was observed that while the spots of exudate were near the disc and macula, the typical silvery, star-shaped figure was not seen. Hemorrhages were uncommon, and when seen were of the small punctate variety. The disc was often affected, either definitely swollen or slightly indistinct at the edges. There were small areas of edema, especially along the course of the veins.

In summarizing, the writer says that in this disease the retina is very liable to be involved, although gross changes are not evident early and later there may have been absorption; that the pathology is probably an acute congestion from some specific toxin, and that the exudate clears up in the majority of instances without leaving permanent results; that the retinal changes do not affect the prognosis, except in so far that the severer these changes the severer the cases, though by no means necessarily so; and that the condition is one which is probably allied to the acute retinitis of pregnancy, scarlatina, and acute uremia, and should not be confounded with the retinitis of chronic kidney inflammation with its permanent changes in the retinal circulation vessels and tissues.

Derby (*Amer. Jour. Ophthal.*, March, 1919, p. 199) reports the unique case of a double retinal detachment occurring in trench nephritis, with gradual reattachment and visual improvement as the renal disease cleared. The patient, 19 years old, had suffered a severe bronchitis two years previously and rheumatism followed this. Thirteen days before admission edema of the face appeared, followed a day later by dyspnea and pains in the legs and feet. The physical examination showed marked edema of face, conjunctiva, limbs and trunk; large tonsils; a systolic murmur in the third intercostal space and a plus second sound. Dullness was found in the posterior bases but no râles; the blood pressure was 145/85. The urine was unmistakably that of an acute nephritis which ran so severe a course that he was on the dangerous list for a considerable time. About two months later the only fundus change found was obscuration of the nasal margins of the discs. At this time, however, the vision began to fail and about two weeks later little vision remained. Subsequently the vision began to return. About three months after the onset of the nephritic symptoms a very marked neuroretinitis was observed with some swelling of the dises and hemorrhages and areas of pigmentation throughout the fundi, together with whitish areas of degeneration. These changes were more apparent in the left eye. Marked separation of the retina downward was found in both eyes reaching almost up to the macular regions and the discs. Vitreous opacities existed in both eyes. At this time the general condition of the patient had bettered decidedly and he stated that his vision was considerably improved. The vision was 6/18 and 6/26 and the fields showed contraction as indicated on the chart. The urine had practically cleared.



Fields of Vision in Retinal Detachment After Improvement Had Begun. (Derby.)

During the next three weeks a diminution in the separation of the retina in each eye was observed and a continuous, though small, improvement in the field of vision was noted. A few fresh hemorrhages were present in the fundi, but the separation had disappeared in each eye about a month after it was first noted. The limits of the field had practically enlarged to normal, being 42 degrees upward in the right eye and 46 degrees in the left. His vision at that time was, right 6/12 minus, and left 6/18 minus. A month after his arrival in England he was heard from and was apparently progressing well.

Hornicker (*Wien. Med. Woch.*, No. 25, 1917), Bergmann (*Deutsch. Med. Woch.,* 1918, p. 520) and Wessely (*Archiv. Ophthal.,* Nov., 1917, p. 538) also have written on war nephritis and its ocular complications.

The cases of *ocular disease following antityphoid vaccination or inoculation* which have been seen in no small numbers probably represent the effect of the bacterial endotoxin either directly, or indirectly, by lighting up some old process, particularly of venereal origin.

Morax (*Ann. d'Ocul.*, cliii, 5 and *ibid,* cliii, 11) reports two cases of herpes consecutive to antityphoid inoculation. In the first case, a slight eruption of herpes on the lower lid followed a second injection, accompanied by slight fever. A third injection, one week later, was followed by rigors and marked increase of temperature. A few days later herpes appeared on the lips and nostril and behind the right ear. Five days subsequently the right eye showed a typical attack of herpetic keratitis. The author also refers to the following three cases of ocular lesions following antityphoid inoculation, but he regards these as coincidences: (1) Paramacular retinal hemorrhage; (2) paralysis of both external recti, associated with generalized paralysis; (3) optic neuritis due to intracranial neoplasm. These four cases were the only instances of ocular lesion observed among 1,700 inoculated soldiers whom he examined. The writer records another case of herpes following a fourth antityphoid inoculation. The eruption had occurred upon the face, eyelids, and cornea.

Gloagen (*Ann. d'Ocul.*, cliii, 5) observed three cases of palpebro-ocular herpes following antityphoid vaccination. In the first case, the first two injections presented nothing of special note; the third was followed by fever, headache and pain in the back, on account of which latter symptom lumbar puncture was performed. On the day following the injection an outbreak of naso-labial herpes, especially intense upon the right side, occurred. Three days later the right eye became congested with photophobia, but the patient was not referred to the ophthalmic clinic until three days after this when herpetic keratitis was noted the delicate ramifications being seen by means of fluorescein. Recovery took place at the end of 18 days leaving, however, a fine corneal opacity which lowered the visual acuity to 6/10.

In the second case, three injections were made without reaction; the fourth was followed by fever and headache. The following morning an extensive naso-labial outbreak of herpes appeared, especially upon the right side; four days later in addition to the palpebral eruption, a typical herpetic keratitis involving almost the entire cornea was observed. Recovery took place at the end of 25 days, with persistence of a slight opacity which reduced the visual acuity to 0.2.

In the third case the same constitutional symptoms followed a first injection. The same night an eruption of naso-labial herpes took place and the next morning there was photophobia of the left eye. Upon admission to the hospital three days later, patches of herpes disseminated upon both lids of the left eye were seen. The cornea was completely covered. Recovery was slow, requiring 43 days and vision was reduced to 1/10.

Ginestous found that one man who complained of impaired vision after anti-typhoid inoculation suffered from a preexisting albuminuric retinitis, and another from tobacco amblyopia. In a third case bilateral keratojunctivitis developed two days after a fourth injection. It was followed by miliary abscesses in the right cornea, and ulceration of the left cornea with perforation. The right eye recovered full vision but the left had a central leucoma. In this case a febrile herpes, accompanying the temperature reaction, may have been due to the vaccination.

Calhoun (*Ophthalmic Record,* Nov., 1917) saw two cases; one of iritis arising one or two days after his first antityphoid and paratyphoid inoculation. The iritis cleared up in about one month leaving full vision. The patient had previously suffered a gonococcus infection. The second patient developed blurred sight with corneal deposits, vitreous opacities and choroiditis a few days after his third inoculation. He had a 4 plus Wassermann. On account of the possible influence of the vaccination in exciting trouble Lapersonne (*Archiv. d'Ophtal.,* Vol. 35, p. 449) urges that it should not be practiced on persons who have suffered from syphilis, arthritis, or tuberculosis.

The eye affections that occur in typhoid and paratyphoid fever Gilbert (*Münch. Med. Woch.,* No. 22, p. 806, 1016) finds include supraorbital neuralgia, which he also saw after antityphoid vaccinations. He reported two cases of metastatic iridocyclitis occurring with paratyphoid.

Wessely (*loc. cit.*) notes the similarity of the courses of the forms of iritis met with in typhoid, paratyphoid and dysentery.

Spirochætosis ictero-hemorrhagica — Weil's disease — Infectious jaundice. This clinical entity, traced by the Japanese investigators Inadu, Ido and others in 1914 to an organism found in the blood, the fresh, centrifugalized urine, or the tissues in general which they have called Spirochæta icterohemorrhagica and for which Noguchi has suggested the name lepidospira, was first observed as a pathological entity of unknown sources in the American Civil war, where many thousand cases occurred. Martin and Petit recorded the appearance of the disease in the French Army in October, 1916, and it was noted among the Belgian troops in August of the same year. On all fronts it was finally recognized in epidemic form. Weekers and Firket (*Arch. d'Ophtal.,* Sept.-Oct., 1917) made the first systematic ocular studies of the condition, which they report in detail. The ocular symptoms met with in the disease are numerous and diverse, including simple hyperemia of the anterior segment of the globe, noted in 29 of Weeker's and Firket's cases; congestion of the iris, seen in 7 cases; iritis with exudation, noted in 6; and sometimes producing synechiæ; optic neuritis, 2 cases; ocular herpes with corneal involvement, 1 case and conjunctival jaundice with extravasation of blood beneath the conjunctiva. It is observed that the congestion of the conjunctiva is secondary to a more or less pronounced ciliary congestion, which betrays the localization of the causal spirochete in the uvea. The spirochætes have been found in the blood and the cerebrospinal fluid, as well as in the liver and kidney, and we need not be surprised that they become fixed in so vascular a tissue as the uvea. Hyperemia of the anterior segment of the eye, congestion of the iris, and iritis are manifestations of different degrees of inflammation of the uveal tract. The redness of the front of the eye may be discrete, but in more marked cases the parts are vividly injected and sometimes intense reactional symptoms may be observed, as photophobia, watering, redness of the eyelids, etc. When examined closely, the redness is seen to involve both the conjunctival and the ciliary vascular system. Subjective symptoms, as a rule, are but slight. The patient sometimes complains of no pain, although more often he experiences a pricking sensation and moderate pain, spontaneously or on pressure. Moderate lachrymation is the rule. Traces of secretion may be found, but it is scanty and does not agglutinate the eyelids during sleep. Simple cases call for no treatment beyond the use of a cleansing lotion. In some instances hyperemia of the anterior segment gives place to congestion of the iris, as recognized by pupillary inequality or contraction, showing that the congestion is not equally marked in the two eyes. The ocular complication may or may not coincide with an elevation of temperature. In grave cases there may be all the symptoms of iritis, or even of iridocyclitis. In these forms atropine and other remedies employed in iritis should be used.

The two cases of optic neuritis reported by Weekers and Firket and similar cases observed by others showed some loss of visual acuity but no field limitation or central scotoma, and visual recovery was complete. These rapid changes are assumed to be due to the presence of spirochætes in the cerebro-spinal fluid of the sheath space of the optic nerve, which sets up changes in the nerves giving the picture of the benign optic retinitis and neuroretinitis in point.

Hertel (*Arch. f. Ophthal.*, Sept. 26, 1917) injected into the peritoneum and eye of rabbits and marmots, material from marmots dead of infectious jaundice and characteristic symptoms resulted, as in the work of Cost and Troisier on guinea pigs. Spirochætes were often found in microscopical section of the eye after intra-peritoneal injection, the conjunctiva, uvea, retina and optic nerve harboring them. van Schevensteen (*Ann. d'Ocul.*, Dec., 1917, cliv, 12) also reports a case of chorioretinitis from this source. In another of his cases there were neuralgic crises affecting the supraorbital and infraorbital nerves on the left side with accompanying photophobia and tearing but without ophthalmoscopic changes. A third case complained of severe pain around and in the eyes and signs of a past iritis were found in one eye.

Moret (*Arch. Med. Belges*, Dec., 1917, p. 1105) studied 72 cases of spirochetosis from the ocular standpoint, two of which developed a definite iritis. He classes the lesions which appear in the eyes during the congestive stage of the disease as vaso-motor disturbances of the external and sometimes of the internal membranes, the hyperemia of the retina and the uveal congestion corresponding to the conjunctival congestion and the general congestive changes. During the period of anemia, however, the signs and symptoms observed in profound anemia, such as asthenopia, and muscæ volitantes, are seen. The retinal anemia and the apparent neuroretinitis which is not in accord with the functional disturbances, are comparable to the similar changes noted in other forms of essential and symptomatic anemia.

Trench fever is a disease which has been recognized and differentiated from other morbid conditions during the recent war, where it was probably one of the largest contributors to the diagnosis of "pyrexia of undetermined origin" (P. U. O.) Both the British and American Trench Fever Commissions have shown that the body louse is the chief agent in the transmission of the virus from man to man, the inoculation occurring probably by the scratching of the feces of infected lice into the skin of men infested with these vermin. From its resemblance to a number of irregular febrile states such as typhoid, influenza and malaria and owing to its variety of manifestation, the exact diagnosis of the condition is often difficult. The general symptoms are those of fever which may be relapsing, continuous in a form-like typhoid or paratyphoid, or, as Swift (*Jour. A. M. A.*, Sept. 13, 1919, p. 807) says "One single short bout resembling influenza: sudden onset with headache, general muscular pain and anorexia, as occurs in other acute infections. "Pink eye" often accompanies the early stage and resembles the conjunctival congestion so frequently seen in influenza. Nystagmus, elicited on extreme lateral rotation of the eyeballs, may be present, as in the weakness of other febrile states."

All forms of acute infectious diseases have occurred among the combatant troops of all the armies engaged in the recent war and usually in epidemic form. Cholera, variola, dysentery, typhus, recurrent fever, pneumonia, meningitis (which in this war has caused ten times as many deaths as typhoid), mumps, scarlatina, measles and influenza appeared at various points or were common to all parts of the field. The ocular findings and complications in these outbreaks were the same as those observed in times of peace and are described in detail in this *Encyclopedia* under their respective headings.

In the discussion of the psychoneuroses acute exophthalmic goiter of war was briefly touched upon, with the comment that this probably represented an induced endocrine imbalance or possibly a local disturbance of sympathetic innervation due to acute changes in cervical alignment.

W. Johnson, writing in the *British Medical Journal* (March 22, 1919), remarks that *temporary exophthalmos* and other signs usually connected with hyperthyroidism were noted in soldiers in "the early stage of advanced conditions of exhaustion." In process of time this disappeared and the patients were then classed in the large group of cases called neurasthenia, as they were indistinguishable from them. This brings Johnson to the conclusion that a large number of so-called psycho-neuroses are in reality suffering from dyscrinism—their symptoms are due to a state of disordered internal secretion—and are the result of emotional exhaustion, coupled with, in less degree, physical exhaustion. Many cases of "soldier's heart," irritable heart, neurasthenia and "shell shock" are really cases of this class, and Johnson hints that there may have been a stage of exophthalmos which was not noticed. He very properly classes the whole group under the term: "Exhaustion syndrome," another name for the conditions grouped under the terms "Neuro-circulatory asthenia," and "Hypoadrenia."

As a by-product of war, among civilian war workers engaged in the manufacture of munitions various forms of chemical poisoning have been noted. Sollier and Jousset (*Clin. Ophthal.*, VIII, 2) report 15 cases of *nitro-phenol optic neuritis* occurring among workers who complained of cloudy vision, cramps and pricking sensations in the legs after handling nitro-phenol for some months. Examination revealed a retrobulbar neuritis which usually terminated in optic atrophy and which is believed to have been caused by the toxic action of the nitro-phenol. As the condition develops very slowly, cessation of the work at the earliest possible period of the disorder prevents the distressing climax which occurred in these neglected cases who came under observation for the first time months after the onset of the visual disturbance.

THE VISUAL REQUIREMENTS OF SOLDIERS

The visual standards in effect among the great armies of the world have been shown by recent experience to have no great relation to military efficiency, with the single exception that the relatively small nuclear forces, such as the first B. E. F. and the U. S. Regulars in whom normal vision was a requisite, proved their incomparable superiority as fighting-men and "dead shots" over the mixed hordes that made up the armies in general and most of whose marksmanship was puerile and ineffective. A trenchant editorial in the *British Journal of Ophthalmology* (January, 1918, p. 40) clearly defines the feeling of many experienced medical men in this matter: "Up to the present time our military standards of vision, which govern the acceptance or rejection of recruits for the army, have been based upon theory and assumption. We have little or no information, derived from actual experimental work in connection with the multifarious functions that soldiers may be called upon to perform, as to what degree of vision is compatible with efficiency in regard to any particular form of military duty. The standards for the various arms have been adopted on the recommendation of military (not medical) officers who reached their conclusions independent of any sort of experimental evidence.

"In earlier days when fighting took place at close range, general physical fitness was looked to and the special senses were but little regarded. Thus we find that as late as 1837 ability to detect a person at ten paces was considered adequate in one continental army. With the advent of weapons of longer range and greater penetration it was presumed that battles would be decided at several hundred yards distance and good vision began to be regarded as a practical necessity. Apart from other essentials, however, we now know that artillery, who may never see their target, are of prime importance, while the final decision in modern war is brought about by bombs, bayonets and even fists. It is now recognized that battles are fought and won by organized hosts of specialists selected and classified according to their individual fitness for their particular functions. *An army has its eyes, its ears, its legs, and its stomach as well as its weapons, and behind all these its brains. Not one, then, but many standards of vision are required and a standard compatible with efficiency in one branch of the service, would be absurd if applied to another.*

"When all that is aimed at is a small standing army of picked men, the question of vision does not arise. It is easy to adopt a high standard and to reject without further inquiry all recruits who fail to reach it. When, however, the number of recruits required in proportion to the population begins to increase, the reasons for rejection require examination. And, finally, when the manhood of a nation is under arms as in this and in future wars, and it becomes necessary to see that the best use is made of each individual unit, theoretical standards can no longer be accepted and the closest scrutiny of the subject becomes essential.

"It has been said that any man who is able to earn a living in civil life is able to be of some use in the army, and while this generalization must have many exceptions, especially when the army is the nation in arms, it is a definite guiding principle that any man, otherwise physically fit, whose vision is such that he can earn a living in civil life, is capable of efficient service in some military capacity. It is common knowledge that workmen often earn full wages with vision that seems to be astonishingly inadequate. It is also necessary to remember that the use of Snellen's test card affords an extremely unsatisfactory index of visual capacity and that the intelligence of the individual is a factor of the greatest importance. An intelligent man with bad vision will be of more use than a stupid man with much better sight.

"The vision required for the different branches of the service can only be ascertained by experience and experiment, by observations made on troops working under war conditions and during manoeuvres.

The unnecessarily high per cent. of present rejections arises from the neglect of the fact that visual efficiency depends more upon the intelligent interpretation of retinal images, even if indistinct, than on the mere existence of clear images.

"When so little is really known about the minimum vision compatible with efficiency in any form of employment, military or otherwise, it would be futile to attempt any minute classification. With regard to infantry, it should be remembered that good vision is only one of the factors involved in good shooting, and, in itself, is not a dependable guide. An examination by Snellen's types of the visual acuity of crack shots would surprise many theorists, especially as many such men are frankly myopic. The soldier who is to shoot should have 6/12 (corrected) in one eye, either the right or the left. Men who are blind in one eye should not be refused. Left eye shots and those who shoot with both eyes open have been found to make good marksmen and are accepted in the French army and probably in others. The abilities of men with only uniocular vision in civil life should be taken into consideration and a practical view should be taken of this question. Men with strabismus, unilateral amblyopia, cataract, traumatic optic atrophy and a large number of other non-progressive morbid conditions in one eye, find themselves in no way impeded in civil life and need be no less efficient as private soldiers than as generals and admirals. The question of testing recruits out of doors at a distance greater than 20 feet, also requires consideration."

In a report of the committee appointed by the Council of the Ophthalmological Society of the U. K., the following is found:

"The general principles which should be taken into consideration in fixing a standard of vision for enlistment into the army are as follows:

"1. That a man's united sight should be sufficient to enable him to find his way about in bright and dim lights and be such as will prevent him from being a danger to his fellows.

"2. That he should not suffer from any progressive disease of the eye, or one likely to recur.

"These two general principles apply to all branches of the service, combatant and non-combatant."

McKee (*Canadian Med. Jour.,* Feb., 1918, p. 108), whose large practical experience and keen observation make his comments worthy of note and of consideration, voices the opinion of many when he says "I feel that a standard of vision without glasses should be insisted upon, for I believe that a recruit with 6/24 vision in the right eye is a more useful soldier than one with 6/12 vision in the right eye by means of glasses. My experience after four years is that the man with 6/24 vision without glasses is much to be preferred. There is only one reason which warrants prescribing glasses for a soldier, and that is that by prescribing glasses you change him from an unfit to a fit soldier. To my mind there is no other excuse which warrants putting glasses on a soldier, and I consider the wholesale refraction of troops and the supply of glasses to combatant forces a grave mistake. Where glasses are ordered, I feel they should be as simple as possible. It is an error to give a soldier with normal vision lenses correcting small degrees of astigmatism and hyperopia."

McKee's views are substantiated and emphasized by the experience of Wallace (*Trans. Ophthal. Soc. U. K.*, Vol. XXXVII, p. 349) who decries those standards of vision which put a man who, without glasses has a vision of 6 60 to 6/20, brought to 6/12 or better by glasses, into the category of a first class fighting man. Experience has proven indubitably that such men are broken reeds in the stress of warfare, being made inefficient at once if their glasses are broken or lost, and often becoming dependent as well and as much trouble as a genuine casualty.

Such standards allow men with grave visual defects, high myopia, dense nebulæ, old iridic adhesions, optic atrophy, disseminated choroiditis, retinitis pigmentosa, cataract, aphakia, vitreous opacities, amblyopia from strabismus and exanopsia, in fact almost an index of ocular disease to pass such tests. Shooting at long ranges is hard on even the best of eyes. The concentrated attention necessary, the sunlight, wind, dust and the irritation of gases arising from burnt powder tax the eye tissues to the limit and are bound to make any ocular defect most apparent at such times. *Shooting with glasses,* especially with the high corrections usually required in the ocular conditions which have reduced the acuity to a border-line degree, is almost useless, and is certainly harmless to the enemy.

Most shooting is done from the prone position, in which the prismatic deflection and the distortion caused by the oblique vision through the upper part of the lenses, about 12 mm. from its center, becomes particularly evident. Deep meniscus lenses and strong decentration would meet this issue but they are as impracticable as would be the adoption of a lens position designed for shooting only. The natural position for a shooting glass is that which keeps the lens parallel with the corneæ in the shooting position, the glass being vertical in such a position so that the eyes can look directly through the lenses rather than at an angle. Lenses so placed, however, are so forced off position that they would be equally impractical for other uses. Stock investigated the question of the direction of the line of vision through a glass in shooting and concludes that the minimum vision for an infantryman is 8/10 and that the correction must be accurate, as an error of ½ D. may render vision insufficient. Astigmatism must be corrected to within 0.25 D. He finds that glasses which cause an astigmatism of ½ D. when looked through obliquely are not useful and faults of adjustment are incessant in the physical hardships of war. Glasses are seldom worn in trench warfare for, when worn beneath a gas mask, it is impossible to keep them clear of moisture and sweat. An additional disadvantage in admitting men with glasses among the fighters is that the demonstration to a man of an optical defect provides him with an obvious method of evading irksome duty, or, if his glasses are broken by accident they form an excuse and often a necessity for reporting sick. With the use of gas masks particularly, myopes of more than 8 D. are placed at an impossible disadvantage as they would be unable to find their way about without their glasses when compelled to don a mask.

McKee clearly states that "The examination which consists only of sight-testing must prove unsatisfactory. The soldier should always have a good field of vision in each eye, and his eyes should be practically free from disease. We demand that the right eye must be the good one. The general objection given for not allowing shooting from the left shoulder is the difficulty in teaching the recruit to get the necessary 'rounds' per minute and that in the trenches men firing from the left shoulder are more or less of a nuisance to the right shoulder shots. Whilst conditions are bound to change, standards of vision that have been latterly adopted seem to me fairly satisfactory. I would certainly recommend no further lowering of the standard. For it is to be remembered that one has to consider not only vision by day, but bear in mind the importance of vision by night. Sentry duty at night is of course one of the most important duties of the soldier. There are in the service men with less than the standard vision, men who are not even fit for home guard duty, passed from one service to another, and from one hospital to another in an extremely vicious circle, no one evidently with the courage, or whatever is required, to say that this man is useless in the army, get him back to civilian duty. It is so simple to pass a recruit not up to the standard, but it is exceedingly difficult to get the army rid of this man, be he as useless as possible. Lowering the standard and enlisting men who fall below the prescribed standard, does no good in the way of helping national defence. On the other hand, it does a great deal of harm, as a useless individual in the army is much more of a nuisance and does more harm than a useless individual in civilian life. The question of standard of vision is by no means a simple one, for no matter what actual standard is demanded there will always be found men with that standard who are unfit and men below the standard who are fit. So much depends upon the individual whether he is 'keen' or not. I consider a soldier who is anxious to do his duty and has only 6/24 vision in each eye, infinitely more useful and a better soldier in every respect than the disgruntled one with 6/6 in each eye. There is also a certain proportion with mental amblyopia, among whom the amount of vision is not much of an indication of their usefulness. The military point of view should teach a medical officer to judge his patient and considerable latitude should be allowed to the military ophthalmologist as to who 'sees to shoot' and who 'sees enough for ordinary purposes.' "

McKee criticizes the general demand for various standards of vision to accord with the necessities of the form of military work to be done, on the ground that "What actually happens is that a man with vision compatible with efficient service in one branch is transferred to another where his vision makes him inefficient and perhaps a nuisance. Men are constantly changed from one service to another, and in cases of great emergency, such as have occurred in the not distant past, even non-combatant units have been called upon constantly to take up combatant duty. It has been suggested that it is easy to adopt a high standard of vision and to reject without further enquiry all recruits who fail to reach it. It is, as a matter of fact, not so easy as it may seem, I only wish it were, for, if the standard of vision had been adhered to, I feel sure millions would have been saved to this country. Lowering the standard of vision will increase the number of passed recruits marked 'fit for service,' but it will not increase the number of bayonets, and it will very materially lower the efficiency of the army."

To show the failure to live up to the standards already adopted McKee cites a number of cases, out of hundreds, in which the men had been admitted to active service with vision varying from blindness in one eye and 6/60 vision in the other, myopia of 25 to 30 D. which gave only perception of light to visions ranging from perception of finger-movement to 6/36 in each eye produced by high astigmatism, nystagmus, retinitis pigmentosa and the like. These men are absolutely incapable of any military work, but they will all be fully capable of attributing their disability to service, and demanding a pension when that time comes. From the low standpoint of cost, this is a large question. The medical officer who lowers the standard and passes an unfit recruit does his country harm from more than one point of view.

Krueckmann (*Heidelberg Ophthal. Congress,* 1916) includes interstitial keratitis, iritis, particularly in its plastic forms and iridocyclitis and glaucoma among the absolute bars to enlistment. Cirincione (*loc. cit.*) further adds complete ptosis, permanent obstruction of both lachrymal canals especially in view of the unusual dangers in which such cases are exposed in gassing, exophthalmos with a projection of over 1 cm., total xerosis, retinal detachment, and vision of not better than 3/10 in both eyes. Vitreous opacities, paralytic and cicatricial lagophthalmos, essential nystagmus, paralytic strabismus and binocular diplopia if they represent permanent and incorrigible residual defects also furnish grounds for absolute exclusion. The majority opinion seems to be that while it is justifiable to remove cataracts, to perform optical iridectomy, remove pterygia and to do other operative work in cases where this is essential for vision of a sort which alone would make it possible for a man to partake of some form of auxiliary service, yet that the correction of strabismus in an amblyopic or a seeing eye, the removal of cataract when the other eye is normal and functioning well, and similar non-essential operations are unwise, especially as they furnish a starting point for malingery and for an attempt to obtain a pension. Miner's nystagmus, when it appears only in the dark and on looking upward does not interfere with the demands of the service.

Relative to the acceptance of cases of unilateral vision from disuse, high astigmatism and aphakia subsequent to traumatic and operated congenital cataract it may be remembered that a certain amount of vision returns to the involved eye under the compulsion of use. Genet (*Ann. d'Ocul.,* cliii, 6) estimated the proportion of the blind in one eye before the outbreak of the war to be 0.81 per 1000 among men between the ages of 23 and 42. Elschnig states that in spite of the great number of myopes in the German Army very few traumatic detachments of the retina have been observed among them and very few injuries from spectacle glass have occurred. According to Doyne (*loc. cit.*) the continuous and excessive glare of the desert in Mesopotamia and similar latitudes is particularly hard on eyes with myopia or myopic astigmatism of degree. With or without correction men so afflicted are of little military value under these trying conditions.

Carson, discussing greater than 0.75 D. is likely to interfere with the ability to sharply focus both of the interesting lines in the telescopic sights of the large guns. A marked amount of hyperopia is undesirable in a gunpointer since in the stress of practice or in action the vision may become blurred from relaxation of the accommodation in the same manner as occurs not infrequently after civilian accidents and nervous shocks. To a similar origin may also be ascribed the not unusual cases of diplopia and the rarer nystagmus which follow the extraordinary straining and psychic changes of battle. Here a simple heterophoria of low degree, but previously latent, has become manifest muscle imbalance.

THE WELFARE OF THE WAR BLIND.

The warm and sympathetic response throughout the world to the peculiar handicaps and problems of the men blinded in war, the world-wide recognition of the debt owed these men for the fullness of their sacrifice in the common interests, the centralization of effort in behalf of their immediate mental rehabilitation, their subsequent training and their final position in the world of workers, and finally the earnest and energetic reaction of the blinded themselves to their own situation, have transformed a problem which threatened to become one of the saddest of the war, to one of the most cheering demonstrations which the world has ever witnessed of the ability of men to conquer their gravest physical handicaps with serenity.

Probably the most convincing contributions to the solution of this problem are those relating to the success of the institution established at St. Dunstan's, in London, England, by Sir Arthur Pearson, no less than to the personal inspiration of this blind leader himself. Lawson (Abstr. *Amer. Jour. Ophthal.,* Jan., 1918, p. 242) gives an excellent account of the work at St. Dunstan's. "In addition to the London accommodations for four hundred men, four convalescent homes outside the metropolis serve a useful purpose in providing the men with trips for rebuilding their health. The condition of admission is that the patient's sight shall have been so injured that he is incapable of leading an independent existence. The great factor in the success which has attended St. Dunstan's is stated to be the youth of most of the patients. Lawson remarks, it is far better to go blind young than to lose sight after middle age. The men are taught to shun self-pity, and are encouraged to accept their lot as an inconvenience and not as a disability. A further important point in training is the teaching of independence.

"In actual training the blind men are given a working-day of four hours, two hours being given up daily to the study of Braille and typewriting, and two hours to the learning of handicrafts or trades. It is found that the intense concentration necessary in the blind, for mental visualization of everything that is learned, produces fatigue in a relatively short time. Two of the rougher trades are usually learned by each man; except in the case of a few who are especially adapted to such occupations as massage, poultry-farming, and telephoning."

In opening a discussion on the employment of the blind, Pearson, who is himself blind, emphasizes the importance of utilizing blind teachers for the teaching of the blind. The blind teacher is paid a salary on the regular basis. Nothing is more encouraging to the blind man than to be taken hold of and shown how to do things by one who was himself blinded only a few months earlier.

"At St. Dunstan's the writing of shorthand is mastered by the blind in seven or eight months, and these blind men have shown themselves capable of doing efficiently the ordinary work of shorthand correspondence clerks. The blind man is taught not only to work but also to play; his recreational opportunities including reading and typewriting, playing games, and playing on some musical instrument, or singing. A great deal of attention is devoted to physical exercise, which includes rowing, walking, swimming, and tandem-cycling."

In the third annual report of St. Dunstan's Sir Arthur Pearson contests the German estimate of two thousand blind in the spring of 1917, within the definition of blindness (V. equals 1-25th) accepted by the German War Office. At that date the English figure was about 800 and the French 2,500.

The War Risk Insurance Bureau has issued the statement (*Jour. A. M. A.*, May 10, 1919, p. 1373) that about 125 men of the American Expeditionary Force were blinded in the war, and the experience of the French indicates that less than one-half of 1 per cent. of the soldiers wounded in battle are blinded, the accepted definition of blindness being that degree of visual loss which prevents the performance of work for which eyesight is essential.

Casey A. Wood (*Amer. Jour. Ophthal.*, Jan., 1919, p. 47) gives an excellent summary of the work accomplished for America's war blind. A careful study was made of the methods in successful use in other countries and these were modified according to our national requirements. As a result there was an immediate and organized endeavor to teach the disabled man that his disability was not hopeless as he conceived it to be; that the surgeon-general and other governmental agencies would undertake to refit him for industry, his industrial training continuing without time limit until perfected; that he and his family would not lack support while he was undergoing instruction; that his insurance compensation for disability would not be reduced as a result of his increased powers through re-education; that a desirable position would be found for him which would enable him to become an independent, self-supporting citizen, taking part in and enjoying the daily life of his own community and finally, that an aftercare department would look after his interests and find a market for his products when he went out into the world, a department found necessary in the early period of his contact with the world in order to correct the mistakes which so easily become habit without the worker's knowledge, as well as to protect him against the unscrupulous and in buying. This cheerful campaign, conducted at first by the army nurses and medical officers was nearly always successful after more or less of an initial moral struggle. As Wood says:

"The disabled soldier's decision as to his future must be backed up by the unhesitating support of his community. No system of governmental or private vocational education can succeed unless the man's will to succeed is stimulated and his ambition aroused by a well-developed public opinion. No Government bureau can exercise authority over the man's personal will to make or neglect his future. For example, it is easy to imagine what a powerful influence the supporting opinion of the family and of the neighbors may be in inducing a man to forego the false glitter of an immediate job in favor of the sound metal of thorough training for an independent future. To convert the man to the wiser view, it will sometimes be necessary to convert his family first. Certainly his friends, relatives and companions must believe in the desirability of this victory over wounds, and this will to conquer difficulties, if the disabled man is to be successful in the contest with the powers of darkness."

It must be remembered that many blinded soldiers will, in addition, be suffering from other forms of disability. In blindness caused in the industries, 98 per cent. of the eye injuries are without such complications, whereas in war 40 per cent. are multiple; that is, these blind men also have amputations of arms or legs, or both, facial burns, destruction of jaws, and so on.

As soon as the American soldiers, blinded in battle recover from their immediate wounds at the base hospital, the special work for them is commenced. At first, the chief effort is to amuse them and inspire them with some degree of hope. Later, as the men improve, they are concentrated at the port of embarkation in France, under care of a special staff which gives the necessary elementary instruction, teaching the men to get about and care for their immediate needs; in other words, teaching them "how to be blind," or, as Pearson more cheerfully expresses it, teaching them "how to learn to see."

On the way home they are grouped according to the degree of injury, and upon arrival in the United States they are sent to the United States Military General Hospital No. 7 at Baltimore for further medical and surgical treatment and special teaching. The technical training given by the Government is the very best obtainable and only paid professional instructors are permitted to give it. The idea of the Government is to place every blinded man in a condition to take care of himself and those dependent upon him.

Where it is possible for a soldier to return to his old occupation, or one allied to it, the aim is to have him do so. Otherwise a special suitable occupation is taught, and in many cases it is hoped that the man will be able to command a larger salary after taking the training than before he lost his sight. Among the trades and professions which are taught are broom-making, mattress-making, rug and carpet weaving, telephone operation, farm work, mat making, tuning in piano factories, winding of coils for armatures, piano tuning as an individual trade, salesmanship, massage, typewriting and dictaphone operating. There will also be ample facilities for recreation in the school, including table games, dancing, singing, cross-country walking, roller skating, attendance at theatres, musicals, and other entertainments, medicine ball, push ball, punching bag, relay races, gymnastics, field sports, running, climbing, swimming, diving, and skating.

The physical training of the blind is a most important factor in their progress in that it makes up for the lack of normal freedom of bodily movement which otherwise results from the natural physical restrictions arising from uncertainty of the relation of surrounding objects. In this connection Sir Arthur Pearson explains the sense of proximity to obstacles, which is so highly developed in the blind, as due to echo, to the difference of air pressure and to differences of temperature. The first is absent in a carpeted room, the third only slightly operative, but in the open each plays its effective part. The abiding danger to a blind person, according to Pearson, is a door half open and where there are blind people every door should be kept shut save when it is actually in use. It is always best for the blind to walk erect so that if an upright obstacle is encountered the foot strikes it first.

Some of the most interesting features of the general plan are made possible by the supplemental Red Cross appropriation. The Red Cross Institute, for example, undertakes to provide a home and transportation to Baltimore for the relative who will be responsible for the care of the blinded man when returned to his home. *It is the intention to instruct one such relative in the Government training school side by side with the blinded soldier, as is now done in the British and French armies. The purpose is that the blind man's family may be informed as to his difficulties, ambitions, training, and needs, so as to prevent the mental deterioration which often results from false sympathy.* Friendly relations between the family and teachers are a potent means of stimulating the interest of the blind man.

The *fundamental principle* which has been adopted in connection with this service is to hold the men in the control of the United States Army as pupil patients until their industrial handicap has been overcome or minimized. It has been found, in studying methods adopted by the various co-belligerents, that the retention of the soldier until his handicap is removed, is the *only safe procedure.* In the French and Italian armies, where this method is pursued, all men get their re-education before they are dismissed; therefore, all men with this disqualification or handicap are obliged to accept the type of treatment which is instituted.

In the British army, for example, where men presenting defects of hearing or speech are discharged, it has been found that re-education is not taken up by 74 per cent. Indeed, all efforts have been made by the Aural Commission in Great Britain through propaganda, through entertainments, through the offer of meals, etc., to entice these men back to accept re-education. To the many who wish to work they have even offered evening classes, and yet they do not avail themselves of it, except to the extent of 24 per cent.

It is felt, therefore, that centralizing all such cases and holding them in the service is by far the safest, sanest, and most certain means to accomplish the purpose of re-education.

Finally, it is well to remember and to place strongly before the public that these men who are being re-educated are not abnormal, but simply have become handicapped through the loss of a special sense in their service to the common cause of liberty.

For several reasons, including the difficulty of teaching Braille to the average man blinded in the war, Cantonnet (*Arch. d'Ophtal.*, Vol. 35,p. 605; Abstr. *Amer. Jour. Ophth.*, Dec. 18, p. 242) has devised a raised writing in the usual characters. It is stated that those with sight can use this form of writing at the first attempt, that the intelligent blind with nimble fingers learn it in one-half hour, and that even the unintelligent can learn it within two hours. The letters, punctuation, and figures are those ordinarily employed. The writing is done with a Braille instrument, by using a special copper reglet, which has three small grooves for each letter, so that with each groove three dots can be made and with the three grooves nine points are possible.

The advantages of Braille over this method of Cantonnet are that the former can be used for stenography and music; and takes up somewhat less space, as there are only six points instead of nine. Each method has its own indications. One special advantage of the Cantonnet method is that the blind who wish to correspond with persons ignorant of blind writing can do so.

The bibliography of this important subject includes the Report of the Committee on the Welfare of the Blind in England (*Brit. Med. Jour.,* Dec. 15, 1917), in which the conclusion was reached that as a general rule the earning capacity of the blind worker could not be placed beyond half that of the seeing worker, and that, as a rule, home industries produced only one-half to two-thirds of the wages earned in work-shops. Further comprehensive contributions to this subject have been made by Bordley (*Jour. A. M. A.,* Vol. 70, p. 1931); Loeb (*Amer. Jour. Ophthal.,* Vol. 1, p. 374); Cosse and Delord (*Ann. d'Ocul.,* Vol. 154, p. 307); Kruckmann (*Wien. med. Woch.,* No. 44, p. 1654); Swinnerton (*Bost. Med. and Surg. Jour.,* Vol. 176, p. 803); Elschnig (*Klin. M. f. Augh.,* Vol. 61, p. 496); Schmeichler (*Wien. med. Woch.,* Oct. 9 and 16, 1918); Axenfeld (*Klin. M. f. Augh.,* Vol. 58, p. 275); Uhthoff (*Klin. M. f. Augh.,* Vol. 58, p. 431); von Szily (*Atlas der Kriegsaugenheilkunde,* Vol. 2, Chapt. XI).

THE RELATION OF THE EYES TO AVIATION.

In the initial consideration of this subject it is well to remember that while theory would assume for the flyer the essentials of normal visual acuity, perfect stereoscopic vision, accurate color perception, the correct judgment of distance with a faultless muscular balance both for distance and near, yet experience in all the combatant armies has shown that, like many of the world's best riflemen, a number of the most famed military aviators were deficient in one or another of the qualifications assumed to be essential. It is further important to keep in mind that the necessities of military aviation, where the lives of tens of thousands or the fate of an army may be in the keeping of one man, become matters merely of individual choice or risk in peace time aviation. In the latter sphere there is no compelling need for the essential acute aërial acrobatics, the unprecedented altitudes and sudden, perilous landings of aërial warfare which strain both aviator and mount to the utmost and deservedly require the highest qualifications, but rather the demand is for the simple ability to fly in approximately straight lines, on even keel and at an altitude seldom greater than two or three thousand feet, with uncomplicated landings at the journeys' end. It requires little reasoning to see that a visual acuity of 6/6 in each eye is probably no more essential under peace-time conditions than is the need for correct color appreciation, or for perfect response to the tests for equilibrium. We have become so accustomed to the lack of perfect coincidence between theory and practice in all of life's problems that while we recognize and urge the need for the highest standards in military aviation (with enough elasticity of regulations to allow the admission of obviously worthy men who lack some theoretical essential) yet we feel that these excessively high standards should not be taken as the measure of peace time aviation for which instead, regulations which shall apply equally to all without the sacrifice of safety must be determined by experience and experiment.

That there is a certain range, of greater or lesser breadth, through which the external factors of the environment may be varied and yet be met by an automatic adjustment of the physiologic processes in the body, which will preserve the vital balance of the mechanism, is especially shown in the rapidly variable stresses of military aviation and particularly in the case of men who are lacking to some extent in the requisite physical essentials. The eyes, ears, cardiovascular mechanism and the nervous system play a part in these adjustments and until the effect of the airman's activities and environment on the functions of the different organs are accurately known neither the qualifications absolutely essential for aviation can be stated with precision nor can the health and efficiency of the aviator be fully safeguarded. And yet, when all is known of reaction to laboratory tests, the intelligence and the power of correctly interpreting what is seen and felt are factors which will often more than compensate for apparently inadequate vision and imperfect reactions. Duane expresses our opinion of this matter accurately when he states:

"We must always consider whether the tests that we make actually show what we wish to determine, i. e., a man's real availability for the work that he has to perform. In other words, are the man's eyes, when tested, functionating under the same conditions as they do in actual practice? If they are not, then our tests, unless we make allowance for their fallibility, give us false ideas. To particularize,—Our ordinary visual test is one of sharp contrast, i. e., of black letters on a well illuminated white ground, or *vice versa*. Never, in actual practice, has an aviator to deal with contrast of this sort. On the contrary, he is all the time concerned either with objects (flags, semaphore signals, ordinary lights, moving bodies of men, roads, etc.) whose contrast with their surroundings is extremely slight, or else with those (e. g., search-light signals) in which the contrast is extremely vivid. Our laboratory tests should be used only as a preliminary examination, to eliminate the obviously unfit; the ultimate decision as to fitness resting upon examinations made under service conditions, and with objects in their service relations."

There are aviators with defective vision who fly well, probably having learned to modify their visual judgment by preliminary experience as observers. In the *Brit. Jour. Ophthal.*, Aug., 1917, p. 498, are notes of three aviators who have made enviable records and two of whom won decorations for work on the Western front despite considerable degrees of mixed astigmatism. None of these men wore his correction while flying, although the correction brought the vision to normal in each eye, whereas the uncorrected vision in the better eye was 6/9 in one case and 6/12 in the two others, the vision of the worse eye being 6/18, 6/36 and 6/12 respectively. In the man having only 6/36 in one eye there was also imperfect binocular vision and a divergence excess. The comment is made "It is obvious that successful flying can be done quite well with distant vision slightly below normal. On the other hand the necessity for quick and accurate reading of the dials of the various instruments renders the possession of good near vision absolutely essential; and, in our opinion, a low myope with a binocular vision of 6/12, other things being equal, would be a more suitable candidate than a hypermetrope of any considerable degree, even though the distant vision of the latter was 6/5." It is of interest that the official standard for the Royal Flying Corps in 1917 was Pilots—Better eye, 6/12 with correction 6/6. Pilots—Worse eye, 6/18 with correction 6/12. Observers—Better eye, 6/18 with correction 6/9. Observers—Worse eye, 6/18 with correction 6/12.

Wilmer states that a successful combat pilot, with trained air vision, who loses an eye may, in the exigencies of war, be seriously considered for return to a flying status when his confidence is not lessened, he is keen to return and his judgment of speed and distance, so essential in landing, are not impaired. Berens found at Mineola that some men who had lost one eye could still make judgment of distance accurately and quickly. Anderson (*Lancet*, March 6, 1918, p. 397) admits that some pupils who have had a long experience as observers, learn to fly well in spite of imperfect vision and his experience has been that of every aviation service. A final qualification, also not altogether subject to laboratory dictation is that of the flying temperament. It has been said that "an airman's life consists of long spells of idleness punctuated by moments of intense fear." He faces vicissitudes of weather, is always on the look-out for hostile aircraft, watching for the flash of enemy guns and manoeuvering out of range of his shrapnel, taking photographs, noting movements of enemy troops, of rolling stock, submarines, etc., conducting night-bombing raids, landing at night and often facing situations, seemingly inextricable and filled with the gravest peril. In the search for human material, impervious to the kaleidoscopic and well-nigh superhuman demands of such warfare, Wilmer says: "We tried to make the examination practical. We realized that a man might be physically perfect and perfect in pathologic reaction, and yet not be a good fighter or flyer; and, the reverse of this, we recognized that a man might not be in the best physical condition, but possess an aggressive spirit, a spirit of service, which would make him excel a man far superior to himself in these other respects. In this connection, I cannot refrain from mentioning G—, who had never been able to go a consecutive year to school. He was told then that he was, as some would say, nervously unstable. He was a good shot, but physically weak. When he became an aviator, he was shot down eight times and had innumerable accidents; but that wonderful spirit of his conquered all obstacles, and he was soon up and back again. On one occasion, he had just been shot down, and was supposed to be at home recuperating; but he slipped away to a neighboring airdrome, and went up without a machine gun and exposed himself to a German fighter until the latter had fired five rounds at him. Then he came back. When rebuked for his foolishness, he said: 'It was not so foolish as you think. I have been told that a man who is shot down loses his nerve; and I wanted to see whether I had lost mine. I have not.' The physical test is important, and the reaction time is; but if, on living with a man, you find that aggressive spirit, you have a man who is fit to fly."

On the medical officer alone depends the selection of candidates for the air service and obviously only an expert in the eye and ear is competent to apply thoroughly and scientifically the tests demanded in the service. But even when a young man is found to be sound in body and in mind, courageous, cool and with abundant initiative, yet the question "Will he last?" always arises. Even the most experienced examiner cannot predict how a flier will behave in action or whether he will cease to be useful after an accident, or a narrow escape from death. Naturally if his nerve is once gone, his career in the air is at an end. There is no way of ascertaining this vital fact except by constant daily observation after the aviator has begun to "use his own wings," especially in action. Accordingly the study of the flying temperament as it is affected by all conditions, the psychological element that is, is of surpassing importance. The ability to endure comfortably and well high altitudes is dependent on the ease and quickness with which the adaptive responses in the breathing, the blood and the circulation take place. In persons damaged by disease, overwork or unhygienic living, or weakened by inactivity and by loss of sleep, the power of adjustment is as a rule below par. The normal equilibrium of the body is so nicely adjusted that under usual conditions the physiologic balance is largely maintained by adjustments that are made with little or no expenditure of effort.

Under unusual conditions, however, such as the handicap of subnormal vision or heterophorias made manifest by effort, the adjustment of the physiologic balance is made with such difficulty, as a rule, as to give abundant ground for Wilmer's eulogium; "History in all activities of life is replete with tributes to those who have 'made good' in spite of, or by reason of, physical handicaps. Such men have one's deepest admiration, but their forte, as a rule, is not in the air." Wilmer (*Arch. Ophthal.*, Sept., 1919, p. 439) from his exceptional experience says that "Absolute normality of the eyes in one of the greatest physical assets that a flier can possess."

From the foregoing considerations it is evident that the selection, classification and maintenance of the physical efficiency of the flyer become the peculiar concern of the ophthalmologist, the otologist, the neuropsychiatrist, the physiologist and the cardio-vascular expert, grouped in their appropriate spheres in the Air Medical Service of the Army and of the Navy. According to the Air Service Medical Manual issued by the War Department in 1918 and which, together with the Manual of the Medical Research Laboratory, 1918, and the Air Service Medical, 1919, are drawn upon in detail:

"Before our entrance into the war considerable thought had been given to the problem of what should constitute the physical requirements for admission into the aviation service, and medical officers had been in conference with other members of the medical profession who were interested in this question. Due consideration also had been given to the study of the requirements formulated by England, France, and Italy, and also Germany. The examination according to amended blank 609, A. G. O., was put into operation in May, 1917, and it is worthy of note that this same series of tests remains unaltered, even to the minutest detail, up to the present time.

"The judgment applied to the original selection of those to constitute the Air Fighting Force of the United States was not based upon an attempt to decide whether or not the individual selected would be able to fly. It was known that men had been able to fly in spite of one or more physical handicaps, such as having only one leg, having one eye, having tuberculosis, or being cross-eyed, or having one collapsed lung, or being well over 50 years of age. Instances were at hand of those so handicapped who had been able to learn to fly and to fly well. Ultimate economy as well as immediate efficiency indicated unquestionably the wisdom of admitting to training only the very best material. The enormous number of applicants at hand made it possible to maintain the highest standards in selecting men for this service. It had been demonstrated by the experience of our Allies that careful selection would avoid the expense, in time and money, of training large numbers of those who would not make good in the service. Furthermore, our measuring stick was chosen in anticipation of peak-load requirements. It was realized that each man entering the flying service might be called upon to negotiate critical emergencies in the air; that insufficient oxygenation coupled with prolonged nervous tension under high altitude combat conditions, actual injury, sudden changes in circumstances demanding instant decision and action, would require of him the utmost mental and physical capabilities.

"It was only right that we should supply for our air fighters as good if not better planes than those used by the enemy. In the same spirit, it was our duty to bear in mind that when an American aviator met a German aviator the outcome of the encounter might easily depend upon which of the two possessed the better vision and other special senses, the better nervous system, and the better mental and physical equipment in general. The flier starting for the enemy's lines carried with him a certain potential disaster for the Hun. The one-eyed man might succeed; the possession of two eyes, however, would render success more certain. The responsibility of the Air Medical Service in the selection of the flier was that no aviator should fail in his mission against the Hun because of discoverable physical defect.

"When the present war first began, there were but few aeroplanes and those were used indiscriminately for all kinds of work. If an aeroplane and its driver could stay in the air, they were used for any service which an emergency might call for. On one day the pilot might be asked to go across the lines on a reconnaissance mission and with the same machine, which was very limited in climbing ability and speed, he would be called upon on the following day to go into the air to fight. With the coming of improved designs and more skilful managing of aeroplanes by fliers, different types of machines have become classified into special groups for special work. The flying service is now highly specialized. Men are called upon to perform widely diversified classes of work, such as pursuit or scout work, reconnaissance, photography, day or night bombing, artillery observation and for each of these special missions the pilot is provided with a certain type of plane adapted to the work in hand.

"Both the enemy and ourselves divided the machines used for service into two distinct classes: the fighting machines, a fast, quick-climbing type, easily and quickly manoeuvered, and heavier machines, which are slower in action and capable of carrying almost any weight.

"It is easy to see that a fast-climbing machine is bound to carry the pilot to greater heights than the slow, weight-carrying machine. Whereas in 1915, flying rarely exceeding 8,000 to 10,000 feet, through improved designs scouts of today climb to altitudes even as high as 25,000 feet and this height is attained in a very short space of time. The nature of the work of a scout, which is simply hunting out the enemy and attacking him, also necessitates descents from high altitudes at tremendous speed.

"Night-bombing has been carried out at altitudes as low as 300 feet. Day-bombing, in order not to reveal the objective of the flight, and to guard against concentrated anti-aircraft fire, may call for flights at very high altitudes. The possible necessity of attaining such altitudes presents a nice problem when we consider the weight of bombs which must be carried, together with the protective equipment with which the plane must be loaded. Reconnaissance machines rarely get to high altitudes owing to the necessity for more or less close observation of the ground, and machines doing this work must accomplish very low flying even in the face of highly concentrated anti-aircraft fire and enemy activity in order to fulfill their mission. Machines coöperating with the artillery which have to make range corrections for batteries do not often work above 6,000 or 8,000 feet. From this we can see that the machines doing the types of work just mentioned, except day bombing, fly very much lower than the pursuit or scout planes. With their capacity for carrying a larger amount of fuel, they can remain in the air for very long periods. When a long trip is to be made, such as a bombing raid far into the enemy country, at least four or five hours must elapse and the pilot is apt to be fatigued to the limit of his endurance. Especially is this the case in cold weather and under the long strain of an extended flight encountering anti-aircraft fire and enemy planes.

"Pilots of scout machines, on the contrary, owing to the speed and climbing ability possessed by planes built for this type of work, never stay in the air much over two and one-half or three hours on account of being unable to load up their machines with more than a moderate weight of fuel. But they have to go to tremendous heights, they have to change those heights very quickly and very often, and they are subject to quick changes of temperature as well as sudden variations in oxygen content of the air.

"In view of these facts the Air Medical Service realized the importance from a purely military standpoint of careful classification of fliers. The work of the Medical Research Laboratory demonstrated that of each 100 carefully selected fliers only 61 are physically and mentally capable of attaining an altitude of over 20,000 feet with safety; 25 out of each 100 are physically and mentally unsafe at altitudes above 15,000 feet; and 14 out of each 100 are physically and mentally unsafe at altitudes above 8,000 feet. Of that 61 of the 100 are fit for any type of air work; that 25 may do bombing; that 14 should be limited to reconnaissance or night bombing. Such classification of pilots for specific duties constitutes a new factor of conservation and safety to our forces.

"The feature of knowing the limitations of a valuable man spell increased efficiency.

"Just as the pilot is provided with a certain type of plane adapted to the work in hand, so the plane must be provided with a pilot adapted to the work in hand.

"It is true that in the absence of a pilot physically and mentally adapted for high-altitude work it is possible to use one who is adapted only for low-altitude work by equipping him with an apparatus to supply oxygen according to his needs.

"Physiologic studies of men living at high altitude, have proven that a very complex series of changes occur before their bodies become able to live normally with less oxygen. This is acclimatization and this occurs in the man living at high altitudes but not in the aviator who alternates constantly between high and low altitudes.

"The flier must undergo abrupt changes in atmospheric pressure and oxygen supply. Atmospheric pressure plays a very unimportant rôle. The whole problem resolves itself into a deprivation of the normal oxygen supply. The fact that there is 'oxygen want' at high altitudes suggested that any piece of apparatus that would permit the breathing of a reduced amount of oxygen could be used to test the ability of men to withstand high altitudes. By means of a modification of the Flack bag the aviator being tested rebreathes air confined in a tank, from which he gradually consumes the oxygen. As the percentage of oxygen decreases, the aviator, in effect, is slowly ascending to higher altitudes, in the course of 25 to 30 minutes, lowering the oxygen content of the air in the tank to 8 or 7 per cent., the equivalent of an altitude of 25,000 to 28,000 feet.

"The same method is attained by a diluting apparatus, which supplies the desired proportions of a mixture of air and nitrogen directly to a mask placed over the face. All of these tests have been standardized and confirmed by the low pressure tank in which the air is rarefied to correspond to any given altitude.

"By a comparison of the percentage of oxygen to which the aviator succumbs when on the low-oxygen test, it is possible to determine precisely the altitude at which the aviator would fail were he in the air.

"This determination is made on the ground, without danger either to the aviator or to his machine, and has been taken as the basis for the classification of aviators now in use by the Medical Research Laboratories.

"It may be noted that these tests of the ability of an aviator to withstand oxygen reduction could not be made safely in the air, as the effects of oxygen-want are insidious and often the aviator succumbs very suddenly and completely when his limit is reached.

"The effect of low oxygen upon the mental processes of the aviator varies greatly in the individual. The aviator usually becomes mentally inefficient at an altitude at which there is as yet no serious failure of his vital bodily functions. If he were sent to an altitude which his heart could safely stand, his efficiency would nevertheless suffer because his brain is not acting properly. By simple tests of mental alertness during rebreathing it is easy to determine that one flier becomes mentally inefficient at 15,000 feet, in sharp contrast to another aviator who has his full mental powers up to and beyond an altitude of 25,000 feet.

"Low oxygen has a marked effect upon vision. Oxygen-want exaggerates to a marked degree any existing defect of the eyes. In many young healthy men the rebreathing tests made manifest eye defects which may have eluded detection by the most expert examination. Crash reports have demonstrated that a large proportion is due to such eye defects. Again, in night flying it is most important that the flier shall be able 'to see well in the dark.' Many aviators are able to fly well without any difficulty in the daytime, but not at night. Laboratory tests determine definitely which individuals possess the ability to see well at night.

"'Stunting' is essentially an internal-ear problem. During and after rapid turnings the flier's brain is receiving impulses from his semicircular canals. Nothing can control or alter the sending or receiving of these impulses. These impulses produce sensations of motion. Fliers vary greatly in their ability to interpret correctly the significance of these impulses. Experience alone enables the aviator to familiarize himself with the meaning of these impulses; those who develop the greatest ability in this respect naturally fall into the scout-pursuit class. Those who, in spite of training, are still disturbed or bewildered by stunting should be reserved exclusively for straight flying, such as bombing and photography. Again, the peculiar demands of night flying, reducing, as it does, at times to the vanishing point, information coming from the eyes, require a type of flier who possesses the keenest ear sense for the detection of movement.

"The rebreathing test is also very valuable in determining staleness in aviators. As staleness is caused by frequent exposure to high altitudes, evidence of this is easily obtained by means of the rebreathing machine. Where originally a flier was able to tolerate an altitude of 20,000 feet or more before showing certain symptoms of staleness, after flying for 100 hours or more, it is frequently found in reexamination by means of the rebreather that he is stale and is unable to tolerate the oxygen reduction equivalent to 10,000 feet. Incipient cases of staleness are thus easily detected. The detection of the early cases of staleness is of greatest importance in that it makes it possible to ground a man for a certain period and thus enable him to recover entirely, whereas if this condition is not diagnosed early it will progress until a point is reached where it is impossible for the aviator to 'come back' and his services as a flier are thus lost to the country. When the staleness becomes marked the aviator is very liable to faint in the air, thus losing his life and wrecking his machine. By periodically examining aviators the first signs of staleness will be detected early and measures can be taken to conserve the efficiency of those who would otherwise be inevitably lost to the service."

For the maintenance of the corps of fliers at the highest point of physical and mental efficiency the grade of "Flight Surgeon" was created. Further aid to this especially trained and qualified physician was supplied by a Nutrition Officer, whose function was to supervise the mess and prevent the development of digestive ailments of even mild character or cure them dietically if they developed, and by authorization of the grade of "Physical Director" for the additional education of the cadet by means of flying calisthenics. By daily turning and tumbling exercises the cadet, who at first was awkward and bewildered, soon became accustomed to positions and movements to which he had been unused. The Physical Director lived and messed with the cadets, studied their habits, temperaments and physical fitness and advised the Flight Surgeon on these points.

"With expert supervision of the flier's nutrition and exercise, supplementing his own professional knowledge concerning flying and the aviator, the Flight Surgeon neglects nothing of a practical value which can be used in maintaining in the highest degree the physical efficiency of the Air Fighting Force and is prepared at any time to furnish to the Commanding Officer a reliable expert opinion as to each individual's mental and physical fitness for flying duty.

"As a result of this vigilance and care, the signs of deterioration which previously had followed a certain amount of continuous service were recognized at their incipiency and preventive means adopted. This was a new thought in aviation. Up to that time it had been the practice to keep the flier at it until he broke. His breaking was signalized sometimes by simple failure to return from behind the enemy lines; sometimes by becoming mentally and nervously so exhausted as to be of absolutely no use; at other times becoming so physically worn out that even the casual observer would recognize his unfitness for service.

"The old method was to get as much out of a flier as possible, then discard him as useless for further air service.

"While it is not possible to arrive at exact percentages, estimates based upon information from every source in Italy, France, and Great Britain, interviews with commanding officers and medical experts in all the flying centers and at the various fronts, indicate that not 2 per cent. of the fliers lost to active service were put out by the Hun. Failures of the airship are, at the present time, responsible for very limited losses to the service, thanks to the inspections to which they are constantly subjected. Three years ago this statement would not have been true; the mechanical genius of the world has been applied to make the airplane safer and with such effect that it happens only rarely that the flier becomes useless through the fault of the ship. Statements from all sources agree that of the total number of fliers permanently out of flying service, not over 8 per cent. have been rendered unserviceable because of mechanical shortcomings of plane or engine. When it has been stated that 2 per cent. of the total number of fliers incapacitated for further air service were put out by the Hun, and 8 per cent. because of mechanical shortcomings of the airplane, the remaining 90 per cent. looms large, when it is realized that this proportion represents troubles in the flier himself.

"Thanks to the splendid work of the Flight Surgeon and his assistants a steady reduction in the percentage of needless and avoidable casualties has resulted. Just as the Medical Department of the Army has been able to wipe out typhoid fever, and made it possible to construct the Panama Canal by the elimination of yellow fever, so the Air Medical Service is destined to serve by prevention of the crash rather than by 'picking up the pieces' afterwards.

"Medical officers of the various air services had observed that more than half of the injuries sustained in crashes were caused by the aviator striking his head against the cowl. It was suggested that the cowl be cut out so as to give 8 inches more room in front. A report received from the Royal Air Force, Canada, states that since this change in the cowl has been made these head injuries have been practically eliminated. Another suggestion was to lash the safety belt to the machine by a simple rubber shock absorber; the same report states that since this has been done, the number and extent of injuries to the upper abdomen and ribs have been decidedly reduced. The problem of protecting the flier against the extreme cold of high altitudes in winter was partly solved by designing electrically warmed clothing, thereby enabling him to continue his flying under conditions, which, up to that time, had rendered it impossible The problem of enabling a flier to withstand the glare of reflected sunlight above cloud banks and to enable him to pierce camouflage was solved by furnishing him with the 'Noviol' type of goggles. During the first two and one-half years of the war no attempt was made to compensate the flier for his lack of sufficient oxygen in high-altitude work. One British squadron used the Dreyer oxygen apparatus since January, 1917; a report from the British front stated that this squadron performed six times the amount of work of any other similar squadron not supplied with oxygen.

"These are examples of what has already been accomplished towards reducing this 90 per cent.; many other methods are now being developed.''

The reactions set up by stunting, by the orientator or, in lesser extent by the revolving chair, while essentially otic in their vertiginous effects are secondarily ophthalmic through the production of decided nystagmus. The eyes are always drawn in the direction of the endolymph movement and are then quickly jerked back in the opposite direction by impulses from the cerebrum. The subjective sensation of vertigo is always in a direction opposite to the endolymph movement. It is *because* of this vertigo that the person falls in a definite direction, and also, when he attempts to find with his finger an object he has previously touched, he is unable to find it but past-points to the right or left, above or below, depending on the direction and plane of his sensation of vertigo.

Labyrinthine vertigo, therefore, is a false sensation of motion similar to the visual illusion of motion observed when watching a moving train from the window of a stationary coach, both being unavoidable phenomena of normal special sense mechanisms, which, however, the subject easily learns to interpret and disregard.

It is evident that if stimulation of the ear causes a movement of the eyes, there must be a definite nerve pathway from the ear to the eye muscles. Also if ear stimulation produces dizziness, it is evident there must be a nerve pathway from the ear to the cerebral cortex.

Jones (*Jour. A. M. A.*, March 17, 1917, p. 802) on the basis of over 350 pathologic cases, including a considerable number of operations and necropsies, traces the nervous pathway of this complicated mechanism from the ear through the brain-stem, cerebellum, and cerebrum as follows:

''The fibers from the horizontal semicircular canals pass through the eighth nerve to the brain-stem, and enter Deiters' nucleus in the medulla oblongata. At this nucleus the fibers divide, going on the one hand to the posterior longitudinal bundle, through which they are connected with the various eye muscle nuclei, to be distributed through the third, fourth and sixth nerves to the eye muscles themselves. It is this pathway that is responsible for the eye movement. The other pathway goes from Deiters' nucleus through the inferior cerebellar peduncle to the cerebellar nuclei of the same side, from which it proceeds through the right superior cerebellar peduncle to the decussation of the two superior cerebellar peduncles in the base of the cerebral crura; from this point there are two pathways to the cerebral cortex of both sides, but the main pathway goes to the cortex of the opposite side. The cortical centers that receive these fibers are postulated by Mills to be in the posterior portion of the second temporal convolutions adjacent to the cortical areas for hearing. It is this pathway from the horizontal canal to the cerebral cortex, passing through the cerebellum, that is responsible for the production of vertigo on ear stimulation. The fibers from the vertical semicircular canals have a different pathway after entering the brainstem, ascending in the pons to a point above the middle of the pons. At this point the fibers divide, on the one hand going to the posterior longitudinal bundle, to be distributed to the eye muscles; on the other hand the fibers enter the cerebellar nuclei through the middle cerebellar peduncle, from which point their pathway is the same as that of the fibers from the horizontal canal."

The *ocular examination of applicants for detail in the department of military aeronautics* as given in the Manual of the Medical Research Laboratory, pp. 133-163, includes:

"I. *History.* Question the candidate carefully concerning previous or present eye trouble, use of glasses, lachrymation, photophobia and diplopia. If glasses are worn, do symptoms develop when without them?

"II. *Stereoscopic vision.* The ability to appreciate depth and distances by means of binocular vision. The ordinary stereoscope may be used. The cards should be clean and flat. The candidate should have a good light coming over the shoulder directly on the card. The card should be moved back and forth until the point of greatest distinctness is attained. Have the candidate name the sequence of objects from before backward, as he sees them through the stereoscope. This should be done readily and without error, keeping in mind the fact that even though the usual order of seeing the objects on the original card is 9-1-7, 3-2-4, 5-6-8, and 10, the confusion of 4 and 5, 9 and 1, and 8 and 10 occurs in people with normal stereoscopic vision. In case of doubt, use in addition the smaller objects on individual pictures, e. g., on No. 9 from before backward is seen cross, balloon, and flag; No. 8, balloon, cross, rod, and pennant; No. 10, pennant, balloon, and cross. Inability to stereoscope properly is a cause for rejection.

"III. *Ocular movements.* These are tested roughly by requiring both eyes of the candidate to be fixed on the examiner's finger, which is carried from directly in front of the eyes to the right, to the left, up and down. The ocular movements must be regular and identical.

"IV. *Pupillary reactions.* These should be regular and equal when responding to (1) direct, (2) indirect light stimulation, and

(3) to accommodation. Face the candidate, who should be looking into the distance, and place a card as a screen before both eyes. Uncover one eye after a short interval and allow bright daylight to shine into this eye. The resulting contraction of the iris of this eye is called a direct reaction. Repeat the test, but now observe the iris of the shaded eye. If this iris contracts, it is termed the indirect or consensual reaction. Repeat tests on the other eye. With both the candidate's eyes open and uncovered, have him fix on a distant object, then focus on a pencil point held approximately 10 centimeters in front of the eyes. Both irides should contract, which is called the reaction to accommodation.

"V. *External ocular examination.* Place the candidate facing a good light and examine each eye carefully with the aid of a hand lens, noting any abnormality. The eye should be free from disease, congenital or acquired, such as lesions of the cornea, iris, or lens, including affections of the surrounding structures, such as pathological conditions of the lachrymal apparatus, conjunctival deformities, or any affection which would tend to cause blurring of vision if the eyes, unprotected by glasses, were exposed to wind or other unfavorable atmospheric conditions.

"VI. *Ocular nystagmus.* If it occurs on looking straight ahead or laterally, 40° or less, it is a cause for rejection.

"(*a*) Spontaneous ocular nystagmus produced by extreme lateral rotation of the eyes, 50° or more, is not a cause for rejection, as it is found in the normal individual. It is usually manifested by a few oscillating movements, never rotary, which appear when the eyes are first fixed in extreme lateral positions. Select a scleral vessel near the corneal margin as a point for observation.

"VII. *Field of vision.* The confrontation test may be used to determine roughly the limits of the visual field. The field is tested separately for each eye. Place the candidate with his back to the source of light and have him fix the eye under examination (the other eye being covered) upon the examiner's, which is directly opposite at a distance of 2 feet. For example: The candidate's right eye being fixed upon the examiner's left eye; the examiner then moves his fingers in various directions in a plane midway between himself and the candidate, until the limits of indirect vision are reached. The examiner thus compares the candidate's field of vision to his own, and can thus roughly estimate whether normal or not. A restricted field of vision or marked scotoma should be confirmed by the use of a perimeter, as it would be a cause for rejection.

"VIII. *Color vision.* Should be normal. A Jennings test is required. If confusion, the eyes should be tested with a Williams lantern. The Jennings blank, properly filled out, should form a part of the physical record. If the candidate is suspected of having learned the Jennings test, the card and blank may be turned over and punched from the unfinished side.

"IX. *Muscle balance at 20 feet.* A phorometer, with spirit level or maddox rod and rotary prism attached, should be used. Muscle balance is satisfactory, provided there is not more than 1 degree of hyperphoria, 2 degrees of exophoria, or 6 degrees of esophoria (if in this latter case there is a prism divergence or abduction of not less than 6 degrees). In all cases of heterophoria the duction power of the muscles must be taken and recorded.

"(*a*) The screen and parallax test: In case the above-described apparatus is not available, the following method may be used until the proper instruments are obtained:

"The candidate is seated 6 meters from a 5-millimeter light on a black field or a 1 centimeter black dot on a white field, which he fixes intently. Shift a small card quickly from eye to eye and note any movement of the eye as it is uncovered and ask the candidate to describe any movement of the eye or the light. Orthophoria obtains if there is no apparent movement of the eye or the light. Movement of the test object or eye with the card signifies exophoria, against the card, esophoria, and vertical movement hyperphoria. Prisms are placed with the base in for exophoria, out in esophoria and up or down in hyperphoria, until the test object and the eye just begin to move in the opposite direction. The weakest prism which causes reversal of the movement, minus 2 prism degrees, is the measure of the heterophoria. If there are less than 5 degrees of heterophoria, only 1 prism degree is subtracted.

"(*b*) Near point of convergence: A 2-millimeter white-headed pin or a 1-millimeter black dot on a white card is carried toward the subject along a millimeter rule from a distance of 50 centimeters, and the point noted at which one or both eyes cease to fix or diplopia is first noted by the candidate. This point is measured in millimeters from the anterior surface of the cornea. Keep the test object in the mid line, a few degrees below the horizontal plane. A near point greater than 65 millimeters at 25 years of age, and 85 millimeters at 30 years of age is a cause for disqualification.

"X. *Visual acuity.* (*a*) Acuity for distance: Test each eye separately, 20 feet from a well-illuminated card with Snellen letters. Full twenty twentieths vision in each eye is desired, but a candidate may be allowed to miss three letters on the 20/20 line with one eye, provided the other has full 20/20 vision, and all other tests are normal. Visual acuity should be taken without the use of correcting lenses.

"Place a plus 2.00D. sph. before each eye successively while the other eye is covered. A candidate who can still read 20/20 with either eye is disqualified.

"(*b*) Near point, or acuity for near vision is determined separately for each eye by requiring the candidate to read, in a good light, Jaeger test type No. 1, gradually bringing the card toward the uncovered eye until the first blurring of the print is noted.

"The distance of this point from the anterior surface of the cornea, measured in centimeters, is the near point. A distance greater than 11 centimeters at 19 years of age, greater than 13 centimeters at 25 years of age, or greater than 15 centimeters at 30 years of age, disqualifies.

"XI. *Ophthalmoscopic findings.* Drop one drop of a 5 per cent. solution of euphthalmin in each eye. Have the candidate keep his eyes closed. After 15 minutes repeat the drops, then examine 15 minutes later. A solution of cocaine, 4 per cent., may be substituted, cautioning the candidate to keep his eyes closed between instillations. A pathological condition of the fundus, active or quiescent, is a cause for rejection."

Of the men presenting themselves as applicants for the air service, 29.3 per cent. failed to pass the physical examination; and of these 5.9 failed in the eye examination alone; 7 per cent. in two tests, and 8.6 per cent, in three or more tests. Practically 50 per cent. of those rejected failed to meet the eye requirements. Of 59 thus rejected for eye defects, 33 had low visual acuity, 10 had defective color vision, 7 imperfect muscle balance, 5 lacked stereoscopic vision, and 3 were eliminated because of the ophthalmoscopic evidences of disease. Lancaster, discussing research work on ocular problems of aviation states that:

"For the study of the problems of flight the visual function may be divided into the purely sensory or percipient, the adjusting mechanism, and the psychic side of vision. Sensory functions withstand the strain of asphyxiation and fatigue without breakdown. Under this head are the retinal functions of light-sense, color-sense, form-sense. The adjusting mechanisms are three: fixation, focusing, adaptation to light. These are rather complex functions and are likely to break down under strain; whether they will or not in a given case depends upon whether any defect is present, and on how well the defect is compensated, some defects being better compensated than others. To insure the best compensation the mental and physical conditions must be maintained at their best, hence the importance of the 'care of the flier.'

"The psychic side of vision includes stereoscopic vision and various matters of judgment and discrimination based on visual perception. They are not much affected by asphyxiation and fatigue. Investigations are now being carried on regarding stereoscopic vision, and other methods of estimating distances at long range, as to light, sense and adaptation, as to accommodation speed, and as to the relative value of different ways of measuring heterophoria."

Value of the Eye in Aviation.

"I. *Judgment of distance.* Judgment of distance is assisted by the power of stereoscopic vision, and for this reason the eyes of all candidates for admission in the Aviation Section, Signal Corps of the United States Army, have had their binocular vision tested by means of a stereoscope. Inability to stereoscope quickly and accurately is considered a cause for disqualification. We know that if a man loses one eye he is often able to judge distance very accurately with the remaining one, but it requires time for him to develop this power. It would therefore seem logical, at least while we are able to select our men carefully, to accept only those with normal stereoscopic vision.

"Speaking of error of judgment in flying as a cause of aeroplane accidents, Anderson states that this error may occur in getting off the ground, in the air, or when landing. Of the 58 crashes in the 'V' series, this cause accounted for 42—4 in getting off the ground and 38 in landing.

"Of the many examples of error in judgment in flying, perhaps the commonest is when, on landing, the pupil misjudges his distance from the ground and either flattens out too soon and 'pancakes,' with a possible crash, depending on the height, or else flattens out too late and strikes the ground at a great angle, usually overturning and wrecking the machine."

Howard (*Amer. Jour. Ophthal.*, Sept., 1919, p. 656, and *Archiv. Ophthal.,* Sept., 1919, p. 461) concludes that the binocular parallax is the most important of the personal factors which aid us in the judgment of distance and power of depth perception. He presents and describes in detail the tests with an apparatus for determining the factors active in this judgment and their normal limits and states that while the findings with the outdoor test coincide very closely with those of the 6 meter indoor test, they do not warrant its substitution for the latter. The minimal binocular parallactic angle varies greatly with individual and seems to depend upon visual acuity, visual symmetry and muscle balance, to a large extent.

"It is difficult to estimate and account for some of these errors of judgment in flying. In some cases it may be due to insufficient instruction. In other cases, even after prolonged instruction, the pupil may still misjudge distance, and on examination one occasionally finds that his standard of vision is below normal; but, on the other hand, he may be found physically fit, with normal vision and normal muscle balance. In the latter case Anderson believes it may be a question of delayed reactión time, and especially the visual reaction time, upon which the aviator is so much dependent. Normally this reaction time is nineteen one-hundredths or twenty one-hundredths of a second. It may be delayed by fatigue and excesses, but in some individuals who are otherwise physically fit it is found to be much slower than in others."

The test for the simple visual reaction time has not seemed to be of such practical value as the Reeves visual discriminating reaction time test which is of great ophthalmo-psychologic value.

"Hence, in the selecting of candidates for aviation the visual and other reaction times should be normal. By the French medical authorities on aviation candidates are rejected if simple reaction times are found to be of the delayed type. The Italians also seem to lay considerable stress upon simple reaction time. The men who have done the most work in reaction time in this country, are of the opinion that simple reaction time is of little value in the selection of candidates for aviation. The accurate determination of the visual discrimination reaction time and other complex reaction times might be of considerable value. It would seem as though physical condition on a given day and the added strain of low oxygen tension should be taken into consideration in seeking the cause of these accidents. We know that there might be a temporary visual disturbance or weakening of the external ocular muscles, and this might account for some of the accidents. Naturally, examination of the eyes later on might show nothing.

"II. *Normal visual acuity.* As long as we can in this country select only those men with practically perfect vision it would seem well to do this. A man with poor vision will not be able to see an enemy plane as soon as a man with perfect vision. He will not be able to accurately differentiate objects seen from the air in selecting a landing place, and when he has reached the ground he will not see obstructions in his path as clearly as he should. The latter may result in the plane being 'nosed over.' " Normal visual acuity is relatively less needed by the day bomber, whose targets are large; by the night bomber, whose rod vision is more important than that of the cones and by the aërial navigator, who can wear glasses with perfect security. As Wilmer says, "Should some ocular error become manifest in a pilot who is good otherwise, the error should be corrected and the correction given in his goggles. The dangers to which men who depend upon goggles are exposed, however, are that they may become broken, blown off, or fogged or soiled with oil or water.

"In a recent discussion of the physical qualities of aviators all the British officers and physicians taking part agreed that the factor of vision was of the greatest importance, and Clark plead for the use of a cycloplegic in making examinations for admission to the flying corps. During the low oxygen tension test visual acuity diminished in 28 per cent. of the normal men examined and in 37.5 per cent. of the men who were ocularly disqualified for flying.

"III. *Normal color vision.* It is important that the flier have normal color vision in order that he may accurately determine the markings of the different planes, differentiate between signal lights, and in helping him to make landings at night. During the day the discrimination between the color of a building, field, forest, or swamp is essential in selecting a landing place. There has been no change in color vision during the rebreathing test or in the low-pressure chamber." Wilmer says that color recognition plays a most important part in the success of all types of flyers. On all maps generally used by observers, the woods are green, rivers blue, roads yellow, railroads black, towns brown. These maps are used for "spotting" important objects. Sky-rockets, with a parachute, are white, red, or green, and cartridges, with and without parachutes, are of similar colors. Bengal flares, which are used in woods and heavy underbrush, are red and white. The aërodromes use red and green or white light for home-coming planes, while the planes themselves carry a red light on the port and a green light on the starboard side. In a "dog fight," flyers of great experience state it is necessary to recognize the colors on a machine in order to avoid the possibility of shooting down a friend. In artillery work the sense of color is necessary in order to detect false roads, trenches, and guns which have been camouflaged by colored screens, trees, etc. Infantry contact is one of the most trying pieces of work that an aviator is called upon to do. He must be able to recognize, in addition to everything else, the colors of the various uniforms. An observer tells of a pilot who flew three times over a body of troops before he felt it safe for the machine-guns to be used. He had poor vision, and his final decision was made only when he recognized the enemy helmets. All types of flyers over land are liable to have to select quickly a place for forced landing. In this connection it is stated by an experienced flyer that good color vision is necessary to detect differences of color on the ground. A light field indicates stubble; a dark green field, grass or wet, marshy ground; dark green stripes running across fields, water or ditches; yellow. sand; and rough-brown spots, bumps.

"IV. *Field of binocular fixation.* It is important that the aviator be able to carry the eyes as far as possible in various directions without turning his head and without seeing double. If a man has a contracted binocular field of vision, it certainly impairs his efficiency, whether observing, fighting, or flying. In 50 per cent. of the subnormal men examined during the low oxygen tension test we have found contraction of the field of binocular fixation, the contraction being most marked in the upper field.

"V. *Muscle balance.* Normal muscle balance should be insisted upon, for even a small defect may be accentuated by the strain of flying and lack of oxygen and result in diplopia or at least a marked contraction of the field of binocular vision at low altitudes. Exophoria and hyperphoria have been shown to be the most important, due to the fact that the weakness of the ocular muscles caused by the lack of oxygen produces diplopia more readily in exophoria and hyperphoria than in esophoria.

"VI. *Field of vision.* The field of vision should be normal, as the aviator's safety depends to a great extent upon his ability to detect enemy planes or in training his own plane in the various fields while his gaze is fixed straight ahead. The aeroplane and the goggle also do harm in that they restrict the field of vision, and many accidents result from this. Everything should be done to improve the construction of goggles and planes so that the visual field will be restricted as little as possible.

"VII. *The perception of motion and its direction.* The perception of motion and its direction is of great importance to the aviator. Appropriate tests for measuring this have been devised. The best pilots say that they finally develop the power to use the periphery of the retina so that it is of greater value in detecting enemy planes

"VIII. *The importance of the eye in maintaining equilibrium.*

Before going into this, first let it be stated that the subject of equilibration is a complex one and that those of us who have an interest in it from a practical standpoint appreciate the difficulty of the subject and realize that although the aviator may fly when one part of this mechanism is deranged or destroyed, we believe that in selecting men for flying positions that it is well to make sure that all the senses used in this complex act are normal. The most important factors in receiving impressions are deep sensibility, tactile sense, the vestibular apparatus, and the eyes. The central nervous system connections must functionate perfectly to use the information it receives to the best advantage. Finally, the muscles should be in condition to carry out the commands of the central nervous system.

"That many aviators depend largely upon their visual impressions in the maintenance of equilibrium is evidenced by the fact that they often tie a piece of string as a streamer to one of the forward struts, so that they may more readily note the first evidence of a side slip when they are flying in a cloud. In spite of the fact that we miss the visual impressions when they are not received, we are still able to control the plane if the remainder of the balance mechanism is functioning normally.

"IX. *Retinal sensitivity to light.* It is important that the retina be sensitive to light impressions, especially for those men who are carrying out night bombing expeditions. With this in mind, most of the allied nations require special tests for retinal sensitivity." Cobb has pointed out the need for ascertaining the photometric value of the objects to which the night flyer is exposed. Among these one has to consider the varying light value of stars, of clear moonlight, reflections from roads, rivers, towns, the "blinding" effect given by tracer bullets, lights at aërodromes, sky-rockets, cartridges, flares, bursting shells and search-lights. Practically it would seem that one who has a good average speed of adaptation with an average recovery from exposure to light for a brief period, would make a safe night flyer, at least from the visual standpoint. Normality in this quality is perhaps most demanded by the naval aviator who must have good muscle balance, stereoscopic vision and night sight for "the level of the water is difficult to judge, especially when the weather is very calm and at night." "Ships" are slow to answer the controls and heterophoria is a common cause of bad landings. "A test of the contrast sensitivity of the retina is believed to be the most useful for our work, and only men who have normal sensitivity in this respect will be selected for night flying."

The Care of the Flier and the Effect of Altitude and the Strain of Flying on the Eye.

"Even though our aviators have been examined with the greatest care and their eyes are as nearly perfect as nature permits, the adapting mechanism of the human machine, including the eye, was designed for use on earth, and altitude adds an unusual strain. Medical men agree that definite physiologic changes occur in man living at high altitudes which permit them to withstand lack of oxygen, but they believe from the examinations that have been made of fliers that they do not become acclimated, but often show rather rapid physical deterioration."

It is suggested that the full record of the essentials of the ocular examination be kept with the papers of each flier and that a routine monthly examination of the visual acuity, the external eye, the muscle balance, near point of accommodation, the near point of convergence and, if alterations in these be found, the stereoscopic vision should be tested and an ophthalmoscopic examination made.

"The most important ocular symptom is failing vision. The pilot complains that he cannot see the ground clearly in landing and has difficulty in picking out enemy planes. There may be no defect in vision, but there is usually some slight error which was previously correctable by an unconscious muscular effort. The muscles become fatigued, due to the strain of flying, and the defect shows itself.

"Certain individuals with apparent perfect acuity of vision are ocularly weak in that they are unable to make use of both eyes, due to some defect in binocular vision or fusion sense. This interferes somewhat with judgment of distance, and the disability tends to increase under the strain of aviation and lack of oxygen, resulting in bad landings, 'crashes,' and consequent loss of personnel and material. These conditions may often be improved by treatment.

"Irritation, congestion, and inflammation of the conjunctiva and epiphora were common complaints of the fliers at Chanute Field. Most aviators realize the necessity for wearing goggles, but many of them fit poorly, allowing the cold air to strike the eye with great force, most often near the internal canthus where the lachrymal puncta are situated. This probably accounts for the disagreeable symptoms noted. The remedy is found in the wearing of properly fitted goggles and the use two or three times daily of a 2 per cent. boric acid solution containing 1 grain of zinc sulphate to the ounce. In some instances 1 grain of cocaine and 10 to 30 minims of 1-to-1,000 adrenalin chloride may be added to the ounce.

Goggles.

"I. *The glass.* (*a*) Should have an optically plane surface. (*b*) Should have a light transmission of 90 per cent. or over for plain white glass. (*c*) If a colored glass is desired, Noviol 'C,' with a light transmission of 87 per cent., is excellent. Euphos has given great comfort and the glass passes a good test. The retina of the eye is sensitive to the glare, and that is probably one of the causes for physical fatigue of the aviator. The colored lenses shut out most of the ultraviolet rays, and some consider them of great value in bright sunlight, in snow, on water, and above the clouds. Many aviators object to any tint in their lenses, due to the fact that they say they are unable to see as well in a fog and that the color in the lenses changes the color of objects looked at, especially the enemy uniform and the fields in making landings, resulting sometimes in the selection of poor landing places or in the misjudgment of distance. (*d*) Thickness of the glass: The lenses should be 2 or 3 millimeters thick. (*e*) Many aviators insist upon some form of so-called nonbreakable glasses, which is nothing more than two pieces of glass with a piece of celluloid between. This piece of celluloid cuts down the transmission of light between 16 and 19 per cent., and no matter how clear the celluloid is originally, it deteriorates with age and becomes yellow and less transparent. When these glasses are struck with considerable force the glass on the posterior surface splinters off and flies into the eye. Even with these disadvantages, some men insist upon the nonbreakable feature, and perhaps not without reason, for even though the splinters do fly off the back of the glass, the eye closes immediately in an accident, and these small particles would hardly penetrate the lids, and there is no doubt that in some instances the celluloid prevents the driving of large pieces of glass toward the eye.

"II. *Visual field.* It is most important that the aviator have a broad field of vision, and for this reason a large curved glass is desirable. Without a broad field of vision the aviator may not see one of his own planes in time to prevent an accident. Pilots who are doing actual fighting demand a broad visual field above everything else.

"III. *Visual acuity.* It is important that the aviator have keen vision, and for this reason glass with optically plane surfaces should be furnished and a determination made of how much visual acuity is cut down by celluloid.

"IV. *Safety to the eye.* The parts of the goggle which come in contact with the brow, nose, and cheeks should have round edges and be protected by a soft cushion.

"V. *Lightness and strength.* The goggles should be light, so that they will not cause discomfort. They should be simple in construction and yet strongly made.

"VI. *Comfort.* The goggles should not press upon the bridge of the nose so as to produce pain, and the elastic which holds the goggles in place should not be drawn too tight. An adjustable interpupillary distance might be valuable.

"VII. *Cleansing.* Goggles should be easily cleaned, and there should be no place for vermin to hide.

"IX. *Protecting sinuses.* There should be sufficient covering in connection with the goggles to protect the frontal sinus. Aviators often complain of pain in this region when it is left exposed.

"X. *Ventilation.* The goggles should be carefully adjusted so that there are no leaks, especially near the nose, which would permit the wind to strike the internal canthi directly. Most of the aviators who have done fighting at high altitudes believe that the goggles should be equipped with some indirect method of ventilation.

"XI. *Material for lenses.* Glass is best. Celluloid and gelatin smear too easily and celluloid deteriorates too rapidly. Mica chips and cracks.

"XII. *Noninflammable.* The material of which the goggle is composed should be noninflammable and for this reason any woolly material is dangerous, as it burns readily. Incendiary bullets are now being used, and they cause great damage when they strike a gas tank.

"XIII. To further prevent injury to the aviator, all parts of the fuselage or control system which he is liable to strike in falling should be protected by pneumatic cushions.

"Doctors and professional aviators have noticed that during the ascent respirations become more rapid and the heart beats faster up to an altitude of 1,500 meters. At this altitude the vision may become less clear, although a French observer states that at 2,000 meters the visual acuity usually increases by a third by reason of the congestion of all the organs of the head and in particular of the choroid and of the retina. Visual acuity tests carried out under low-oxygen tension on the rebreathing apparatus and in the low-pressure chamber have not shown any marked increase in vision. On the contrary, the improvement, when it occurred, has usually been slight, but more often the vision has remained unchanged and in a few cases has fallen off considerably.

"During the descent, there is another series of phenomena which increases as one approaches the ground. It is first the sensation of smarting of the face with redness and very high color. The eyes sting and are injected. The nostrils are moist and then comes a headache, or more exactly a sort of heavy feeling in the head with a sensation of obstruction. Swelling in the pharynx at the level of the larynx. Finally there is a strong tendency to sleep.

"To explain these difficulties during the descent, one may admit that an airman who falls to the earth in four or five minutes or less, after having attained 3,000 or 4,000 meters of elevation in 20 minutes, had not had time to adapt his circulatory system to the different barometric pressures. From the experimental work done, the change in oxygen tension would seem to be the most important factor in the production of symptoms.

"The question of correcting lenses is an important one and most ophthalmologists feel that it is better in principle not to have vision corrected by lenses, at least as long as we are able to obtain men with nearly perfect vision. The aviator needs perfect vision and a normal ability to distinguish colors, a rapid valuation of distances and the faculty of accommodating rapidly. There have been many accidents described as due to hyperopia, myopia, and astigmatism, and it is a question if it would not be well to use a cycloplegic in the examination of all candidates for admission to the flying corps.

"The research work done in the Medical Research laboratory has shown definitely that a flier's life depends, to a great extent, upon his ability to keep in condition, both mentally and physically. Loss of sleep, dissipation, or illness will so lower his resistance that his eyes break more readily under the added strain of low-oxygen tension, which, in actual flying, would frequently result in death.

"When every flier understands this fact we will have a more efficient flying corps and fewer accidents.

"Aviation medical authorities having reported that aviators in the war zone were using tobacco to excess, smoking while in the air as well as incessantly while on the ground, the problem of the effect of tobacco upon the eye was taken up by the Research Laboratory at Hazelhurst Field and the following conclusions reached: Approximately 75 per cent. of smokers have definite though temporary effects upon vision from a single cigar, and almost an equal proportion show a rise in blood pressure, while there is an increased pulse rate in nearly 90 per cent. This effect is also temporary, although John, in 1913, reported that the use of two cigars caused a rise of blood pressure lasting for two hours after the cessation of smoking.

In 1907 Hesse found similar pressure effects. Nonsmokers have not as yet been tested in numbers to afford a report. Only one enters this series. He showed a fall of 0.3 in visual acuity. Accommodation fell off 15 millimeters. There was apparent reduction in retinal contrastivity of 1 millimeter. Some giddiness occurred at 18 minutes from start, accompanied by slight nausea.''

It is possible that the frequency of hesperanopia in the late combatant armies may be an effect of excessive consumption of tobacco without the occurrence of a typical tobacco amblyopia. Practically the same results are produced by the inhalation of one or two cigarettes as are given by smoking one cigar.

There is little of a specific type in the *ocular accidents and disorders of aviation.* The frequency with which latent refractive errors, notably hyperphoria and small degrees of heterophoria are made manifest by the prolonged ocular concentration has already been noted. Zade reports 165 cases of ring scotoma met with among officers and men of the aviation service. The scotoma begins on the temporal side, assuming first a crescentic and later a circular form, though the ring is often incomplete above. The scotomata for the most part lie very peripherally, are small, usually relative, bilateral and, quite rarely, two concentric rings may be found in one eye. The earliest onset noted was three weeks after beginning duty in this particular service. Involution is very probable. Zade considers the cause to be dazzling by diffuse light. No connection was observed between the refraction or the pigment content of the uvea and the degree of the disorder. Temporary rest and the use of colored glasses on the resumption of active service are recommended.

Graeme Anderson (*Jour. Royal Nav. Med. Serv.*, Vol. IV, No. 1, Jan., 1918, p. 51) in a discussion of aeroplane accidents, shows that the greater number of ''crashes'' which have damaged the aeroplane to a degree necessitating its repair or rebuilding in a workshop, as opposed to ''bad landings'' where the damage is small and can be repaired by flight mechanics, occurs during the first seven solo flights. Naturally, more occur during the first two, with a rapid diminution from the third to the sixth and a rapid rise again in the seventh, suggesting the inference that by the time the pupil arrives at his seventh solo he often becomes over-confident and a little careless.

The causes of aeroplane accidents are enumerated as follows: (1) Defect in aeroplane; (2) error of judgment in flying; (3) loss of head; (4) brain fatigue or lethargy; (5) fear; (6) physical illness; (7) unavoidable causes. Among these, errors of judgment are blamed in 42 out of a total of 58 crashes in 9,000 flights, or 1 in every 560, and of these 4 occurred in getting off the ground and 38 in landing. As examples of "loss of head" which caused 7 out of 58 accidents, the pupil, in an emergency may move the throttle the wrong way, may keep his engine full on when he should throttle down, or may switch off his engine at a moment when he requires all the flying speed possible. Cold and fatigue may produce faintness or stupor in the air. In brain fatigue there is no power "to reason, decide, or act." A state of mental inertia supervenes.

The great majority of "crashes" are fatal at once, or if not, the injuries are so multiple and general that they altogether overshadow the local lesion which may incidentally affect the eyes as in any fall from a height.

Before the cowls of the machines were cut down many ocular injuries occurred as a result of the head striking this portion of the car but these contused and lacerated wounds are seldom seen now. Tyson (*Arch. of Ophthal.*, March, 1918, p. 204) records a case of traumatic paralysis of the left abducens following a collision at 400 feet, both machines falling to the ground. A fractured clavicle and nose and extensive orbital, subconjunctival and subcutaneous hemorrhages were associated with a contused wound of the left brow. The man was left with a traumatic paralysis of the left abducens but without other muscular, pupillary or fundal involvement. As the hemorrhage disappeared, motility improved, favoring the presumption that the injury to the sixth nerve was intraorbital and the prognosis good. Similar traumatic cases have required 6 to 12 weeks for complete recovery, while the few with recovery only partially may represent cases of nuclear injury, of laceration in the course of the sixth nerve over the fossal floor, or of neuro-muscular damage as a residual local defect. Naturally in the cases with basilar involvement, which it may be presumed includes the majority, the usual ocular manifestations of basilar fracture appear.

Descomps, Merle and Quercy (*Bull. Soc. Méd. des Hôp.,* Dec. 13, 1918, p. 1155) state that the uncontrollable abduction of one or both eyeballs which is seen not rarely during rotation tests and which may occur after severe flights and aerial shock, may be associated with relics of paresis of the sixth pair, though it may also be observed with injury of the eighth pair.

Four cases are described with evident lesions in the vestibular or cochlear domain. The convergence of the eyeballs can thus be regarded as an indirect sign of a lesion in the apparatus of hearing, as also of injury of the oculomotor centers or of the centrifugal branch of the reflex arc affecting the motor nerves of the eye. It is a phenomenon that interests not only the neurologist but also eye and ear specialists.

In view of the possibility of more frequent involvement of the sixth pair after aviation injuries, with permanent convergence excess resulting from residual paralysis, it is probable that the operation of muscle-substitution will acquire a far greater future vogue than it enjoys at present.—(L. M.)

Warburg's tincture. A powerful antiperiodic and tonic preparation of quinin sulphate, aloes, rhubarb, with aromatic and other tonic drugs. It is used for its tonic effects in chlorosis and anemia.

Wardrop, James. A famous British surgeon, of much importance in ophthalmology. Born Aug. 4, 1782, at Torbane Hall, Linlithgowshire, Scotland, he studied at Edinburgh, where he was a pupil of his uncle, the celebrated Andrew Wardrop. At nineteen years of age he became house surgeon in the Royal Infirmary. After a year or so in Paris and Vienna he settled in Edinburgh.

In 1808, when only twenty-six years of age, he removed to London, and, on March 18, 1814, became a Member of the Royal College of Surgeons. Because of a lucky cure in the eye of a horse belonging to the Prince of Wales, he was made extraordinary surgeon to the Regent, and in 1828, surgeon to the King. He was also offered a baronetcy, but this he declined.

In 1826 he founded the West London Hospital of Surgery, which he himself supported at his own private cost for eight long years, its doors being always open to brother physicians and to the indigent "without money and without price." His chief performances were in the general field; yet he was also a celebrated ophthalmic operator.

Wardrop was always testy and hard to get along with. Even his friends were bound to admit his extreme stubbornness and unreason. According to one authority, for the last thirty years of his life he was never seen in a medical or surgical gathering of any kind.

Wardrop died Feb. 13, 1869, aged 87 years.

In addition to works of a general character, which are numerous and very valuable, he wrote: 1. Observations on the Effect of Evacuating the Aqueous Humor in Inflammations of the Eyes; and on the Changes Produced in the Transparency of the Cornea, from the Increase or Diminution of the Contents of the Eye-ball. (*Edinburgh Medical Journal,* III, 1807, pp. 56-62.) 2. *Essays on the Morbid Anatomy of the Human Eye.* Vol. I, 1808, Vol. II, 1818. 2d ed., 2 vols., 1834. (The very first book to be devoted exclusively to this subject.) 3. Practical Observations on the Mode of Making the Incision of the Cornea for the Extraction of the Cataract. (*Edinburgh Medical*

Journal, V, 1809, pp. 1-9.) 4. *Observation on Fungus Haematodes, or Soft Cancer, in Several of the Most Important Organs of the Human Body.* (Edinburgh, 1809; Ger. Trans. Leipsie, 1817; Dutch Trans., Amsterdam, 1819.) 5. *History of James Mitchell, a Boy Born Blind and Deaf; with an Account of the Operation Performed for the Recovery of His Sight.* (London, 1813.) 6. Account of the Rheumatic Inflammation of the Eye. (*Med. Chir. Trans.,* X, 1, 1818.) 7. Case of a Lady Born Blind, Who Received Sight at an Advanced Age by the Formation of an Artificial Pupil. (*Philos. Trans.,* 1826.) 8. A Piece of Golden Wire Embedded Upwards of Three Months in the Cornea. (*Lancet,* X, pp. 476-826.) 9. *Sketch of the Life and Writings of the Late Benjamin Gibson, Surgeon in Manchester.* 10. Disorders of the Retina Occasioned by Derangement of the Alimentary Canal. (*Lancet,* XXVII, 1833-4, p. 46.) 11. *Disorders of the Retina Occasioned by Disturbed Action of the Heart.* 12. Scarifying the Conjunctiva. (*Ib.,* XXV, p. 240 and 823.) 13. On the Treatment of Staphyloma. (*Ib.,* XXVII, p. 197.) 14. A remarkable Lusus of the Lacrymal Organs and Conjunctiva. (*Ib.,* p. 344.) 15. On the Analogy in the Diseases of Similar Structures Situated in Different Parts; Illustrated from Gonorrhoea and Purulent Ophthalmia. (*Ib.,* p. 514.) 16. On the Sympathy Between the Eyes. (*Ib.,* XXVII, 1834, 5, p. 616.)—(T. H. S.)

Ward, William Charles Augustus. An English ophthalmologist of great promise, who died young. Born in 1879, he studied at St. Thomas's Hospital, became senior house surgeon at the Royal London Ophthalmic Hospital, and then was made ophthalmic inspector for the Public Health Department, in Egypt. He died in 1911 at the British Ophthalmic Hospital, Jerusalem, aged only 32.—(T. H. S.)

Ware, James. He was a London surgeon, who devoted most of his time to ophthalmology. The date of his birth is unknown, but, probably, it was not far from 1750. He died at London in 1816. Donders (*Refraction and Accommodation,* p. 326) believes that he was probably entitled to the honor of discovering hypermetropia.

His ophthalmologic writings are as follows: 1. *Remarks on the Ophthalmy, Psorophthalmy and Purulent Eye, with Methods of Cure.* (London, 1780.) 2. *Chirurg. Observations Relative to the Epiphora, or Watery Eye, the Scrofulous and Intermittent Ophthalmy,* etc." (2 vols., London, 1782; 1804.) 3. *A Treatise on the Cataract, with Cases.* (London, 1793.) 4. *Enquiry into the Causes which have Prevented Success in the Operation of Extracting the Cataract.* (London, 1795, 1804.) 5. *Remarks on the Fistula Lacrymalis.* (London, 1798.) 6. *Chirurg. Observas. Relative to the Eye.* (2 vols., London, 1798; 2d ed., 1805; 3d ed., 1818.) 7. *Remarks on the Purulent Ophthalmia which has Lately been Epidemical in this Country.* (London, 1808, 8 vo., 57 pp.)—(T. H. S.)

Ware, Lyman. A pioneer Chicago ophthalmologist, one of the founders of the Chicago Ophthalmological Society. Born at Granville, Ill., Nov. 11, 1841, a son of Ralph and Lucinda A. (Clark) Ware, he practised ophthalmology in Chicago for more than forty-five years. After studying in several European clinics he became oculist and aurist to the Presbyterian Hospital and the Chicago Orphan Asylum, and from 1871 to 1889 was surgeon to the Illinois Charitable Eye and Ear Infirmary. One of the founders, in 1880, of the Chicago Ophthalmological Society, he was, in 1889, its vice-president and ten years later its president. He translated into English (by special permission of the author) under the title "*Clinical Studies of Diseases of the Eye*" (Blakiston Son & Co., Phila., 1885) Arlt's Text-Book, a work that was for some time used by medical students especially in western America.

Ware was a small, stoutish man, smooth-faced, of fair complexion and with light-blue eyes and brown hair. He was very polite, quiet and reserved in manner, but a man of much deep feeling. He was fond of general reading, and had a choice collection of rare books. He was a Republican and a Presbyterian; for years an elder in the church.

He married, June 7, 1877, Elizabeth A. Law. His death occurred in Chicago, June 1, 1916.—(T. H. S.)

Warlomont, Evariste. A celebrated Belgian ophthalmologist, for a long time chief editor of the *Annales d'Oculistique.* Born at Aubel, near Liège, Belgium, Nov. 26, 1820, he received the degree of M.D. at Louvain, and then was an army surgeon for about seven years. In 1850 he became editor of the *Annales,* a position which he held until his death, almost 41 years. In 1852 he was made director of the Ophthalmic Institute at Brussels and oculist to the King. In 1860 or '61, he founded the Ophthalmic Institute at San Remo, Italy. He was a very active member of, and was almost always present at, the meetings of the various International Ophthalmologic Congresses. Indeed a number of these affairs well nigh owed their existence to Warlomont. He died at Brussels Jan. 22, 1891, after a long and painful illness.

Warlomont, together with Testelin, translated into French Mackenzie's "*Practical Treatise on Diseases of the Eye.*" He also wrote a large number of articles, which, for the most part, appeared in the *Annales* and in the *Dict. Encyclop. des Sciences.*—(T. H. S.)

Warnatz, Gustav Heinrich. A well known German physician and ophthalmologist. Born Feb. 27, 1810, at Camenz, he received his medical degree in 1832 at Leipsic. For six years he practised general medicine at Camenz, then removed to Dresden, where he also practised general medicine, and became assistant to von Ammon. In 1849 he was appointed physician to the Dresden Institution for the Blind, and died May 18, 1872.—(T. H. S.)

War nephritis. A term suggested by J. Kirk (*British Med. Journ.,* Jan.. 5, 1918) for **Trench nephritis.** See **War, Ophthalmic medicine and surgery in.**

Warner, Joseph. A famous London surgeon of some ophthalmologic importance. Born in 1717, on the Island of Antigua, British W. I., he studied at London under Samuel Sharp, became professor of anatomy at St. Thomas's Hospital and surgeon-in-chief at Guy's—positions which he held for more than forty years. He died in London, aged 84, July 24, 1801.

Besides his numerous and highly important works on general surgery, he wrote *"Description of the Human Eye . . . together with their Principal Diseases"* (London, 1754; 4th ed. in 1784). This work contained no new matter, but is worthy to be remembered because it is the earliest clear, extensive and sensible work on ophthalmology composed by an English writer.—(T. H. S.)

Warren, John Collins. A famous American physician, of some importance in ophthalmology because of his skill as a cataract extractor and because of his having been "the first to describe a case of accidental dislocation of the lens." Born at Boston, Mass., Aug. 1, 1778, son of the Dr. John Warren of Revolutionary fame and founder of the Harvard Medical School, and also a nephew of General (Dr.) Joseph Warren, he was at first intended by his father to be a merchant. Youth, however, had its way, and young John Collins after graduating from Harvard went to Europe in 1799, where he studied at first with William Cooper. Later, he studied with William's nephew, Sir Astley Cooper, and became a dresser at Guy's Hospital. After a year at Edinburgh, and a final year at Paris, he returned to Boston. In 1806 he was made adjunct professor of anatomy and surgery at Harvard, and in 1815, on the death of his father, full professor. His connection with the introduction of the newly discovered ether anesthesia is a well worn story in the history of medicine. He also founded the Massachusetts General Hospital, and assisted in the institution of *"The New England Journal of Medicine and Surgery,"* which, after its union with another publication, was known as *"The Boston Medical and Surgical Journal."* Warren, as stated, was the first to describe a case of accidental dislocation of the crystalline lens (*New England Medical Journal,* 1811) and was also one of the first to call attention to the importance of rheumatic inflammation of the eye

Warren married, in 1803, a daughter of Jonathan Mason. From the union six children were born. In 1843, his first wife having died two years before, he married a daughter of Gov. Thomas L. Winthrop. Dr. Warren died May 4, 1856.—(T. H. S.)

Wart. Verruca. Papilloma. See **Verruca**; and **Papilloma,** p. 9241, Vol. XII of this *Encyclopedia.*

Wash, Black. Lotio nigra. A lotion of calomel, 64 gr., and lime-water (liquor calcis), 16 fl. oz.; used in treating syphilitic sores. See p. 1366, Vol. II; as well as p. 1007, Vol. II of this *Encyclopedia.*

Washes, Eye. See **Collyrium,** p. 2337, Vol. IV of this *Encyclopedia.*

Wasp-sting, Ocular symptoms from. See, also, **Injuries to the eye.** This subject has been to some extent treated under various other captions in this *Encyclopdia.* Here the abstract of a paper by Y. Yoshida (*Am. Journ. Ophthalmology,* p. 494, 1920; trans. by S. R. Gifford) fully covers the ground. He points out that the ocular changes provoked by bee and wasp stings are quite varied. Cases with stings of the lids have been reported by Zander-Geissler (1864), Hilbert (1904), Gepner (1907), Kraupa (1911), Purtscher (1911), and Orendorff (1911). Among these, in the cases of Gepner, Kraupa and Orendorff, there occurred also a keratitis, which took place secondarily by extension of the sting to the conjunctival surface.

Direct trauma to the cornea by wasp and bee stings is noted by Krieg (1842), Purtscher (1895), Gallemaerts (1896), Lewin and Guillery (1904), Leplat (1894), Kaufmann (1904), Joachim (1904), Huwald (1904), Luniewski (1906), Kusama (1913), Koyanagi (1920).

As rare changes, Hilbert and Lewin-Guillery noted discoloration of the iris (the first, greenish discoloration of the iris); Huwald and Kaufmann clouding of the lens; Lundy acute glaucoma; Koyanagi acute glaucoma and cataract.

Concerning the pathologic anatomy, we know nothing as to the cause of the peculiar bluish discoloration of the iris. Huwald, Langer, Nagano-Oda, and Koyanagi have, indeed, investigated pathologic changes after wounds of this kind by the experimental method; and have, in a praiseworthy way, brought much to light. Of the cause of the iris discoloration, however, they have made no mention, as they did not succeed in producing this interesting bluish discoloration experimentally.

Recently Yoshida had occasion to observe a case of keratitis due to wasp sting, in which, besides the corneal changes, bluish discoloration of the iris occurred. A piece of the iris so affected was secured, and was used for microscopic examination.

The case concerned a forty-six year old farmer. A wasp suddenly stung him in the left eye. Pain, lachrymation, and swelling of the lids followed at once, which disappeared after about twelve hours. The next day, however, he found that vision was poor in the left eye.

Ocular movements were free. The left palpebral fissure narrower than the right, since the skin of the lids was somewhat reddened and swollen. No remains of the sting could be seen. Lachrymal sac intact. The palpebral conjunctiva showed nothing abnormal, except slight hyperemia. The bulbar conjunctiva was only slightly injected around the limbus.

The cornea showed in its entire extent a diffuse, grayish opacity; which on examination with the loupe was seen to consist of numerous fine points, and which was more opaque in the center than peripherally. The single points were both superficial and deep. The opacity showed no formation of new vessels. The whole surface of the cornea presented fine inequalities, and in the middle, a few vesicles from milium to pinhead size. A foreign body was not found in the cornea. The striate opacity of the cornea mentioned several times in the literature was not observed. The sensitiveness of the cornea was wholly obliterated.

The sclera was intact. The anterior chamber of normal depth, and showed no hypopyon. The pupil was about 7 mm. in diameter (atropin mydriasis), perfectly round and showed no posterior synechiæ.

The most striking change in the iris was its bluish discoloration. This was the more notable as the iris of the other eye was of a brownish color. The peripheral part of the iris on the affected side, however, showed a brownish color, this part had thus been spared by the pathologic change. The markings of the iris appeared more or less notably washed out; but its exact examination was impossible on account of the corneal opacity.

The lens showed in its center a superficial, irregularly outlined localized opacity. From the pupil a red reflex was barely obtained. Tension minus. L. V. = Fingers at two feet, not improved by glasses. Projection good.

The right eye had normal vision and showed nothing pathologic; the iris particularly showed a brownish color.

As treatment, hot applications, 5 per cent. dionin ointment, subconjunctival injections of Na.Cl., a pressure bandage, etc., were employed. By these means the corneal opacity was somewhat improved. But there remained in the center a dense opacity, in which vesicle formation frequently recurred, without, however, any accompanying increase in tension.

Two weeks after admission, blood vessels appeared in the deeper layers of the cornea. The pupil remained dilated and did not react to light, though no more atropin was employed.

An optical iridectomy was done above, and the patient was discharged with vision fingers at 2 feet.

The fragment of iris secured measured 2 mm. in breadth by 1.5 mm. in height. It was at once fixed in 10 per cent. formalin, embedded in celloidin and cut serially in sagittal sections.

The striking finding to be observed in the iris was the absence of its anterior limiting membrane, together with its endothelium; so that the vascular layer was laid bare. In several sections at the pupillary border the sphincter was entirely bare. The remaining tissue of the anterior stroma, now limited anteriorly by the free surface and extending posteriorly directly to the vascular layer proper, was unusually swollen; so that the characteristic reticular structure of this tissue could no longer be made out. It had, on the whole, a smooth surface, but in parts presented deep furrows, and stained much less deeply with eosin than the vascular layer beneath.

Another noteworthy finding was the presence of a peculiar hyalin-like mass on the free anterior surface of the iris. The latter showed a flat configuration, was about .3μ to 1μ thick, firmly adherent here and there to the surface of the iris, larger towards the pupil than towards the ciliary region, and in many places turned forward at both ends, or curled over. At the places where it showed a deepening on the surface of the iris, it penetrated, wedge-like, into the iris. It stained red with eosin, yellow with Van Gieson-Weigert, violet-red with Russell's stain, pale-blue with Weigert's fibrin method, rose-red with Loele's stain, and violet-red with Pappenheim's methyl pyronia green.

In general, it appeared homogeneous, but contained here and there shrunken nuclei of leucocytes and pigment granules; and was sharply differentiated from the underlying iris tissue. In places it appeared more or less distinctly divided into leaves or processes, and showed small lacunæ, which are chiefly placed with their long axes parallel to the iris surface. It was, however, nowhere reticular.

In other respects the iris tissue presented a normal appearance; nowhere was pathologic engorgement of vessels and inflammatory invasion of leucocytes to be seen. The vessels themselves were likewise unchanged. The posterior limiting membrane and pigment cells of the pars iridica retinæ were normal. The sphincter muscle was, as already mentioned, partially denuded of its covering anterior stroma layer, so it was left bare in places. Its muscular tissue appeared somewhat swollen and enclosed many vacuoles; its nuclei, however, took the stain well.

"That the peculiar bluish discoloration of the iris in the case was the direct result of wasp sting, and did not concern a so-called heterochromia, is clear enough from the above described histologic findings. Of these, the following are to be emphasized as especially important:

"1. The absence of the entire superficial structure, of the anterior stroma layer.

"2. The presence in places of peculiar hyalin-like masses on the free surface of the iris.

"The staining properties of the latter are not, as above mentioned, quite typical for hyalin. That they cannot, however, concern fibrin which has exuded onto the iris surface, is apparent from their flat form, homogeneous appearance and nonreticular structure. Against this, also, is the fact that the ocular changes evoked by bee and wasp stings are predominantly of a degenerative type. The lens opacity in bee and wasp sting is, for example, not to be considered as belonging to the usual picture of traumatic cataract. The vesicle formation on the corneal surface must have its origin in degeneration of the epithelium.

"Huwald in his experiment found necrosis of the anterior iris endothelium, without, however, any discoloration of the iris. Nagano and Oda also describe a necrotic change of the endothelium on the posterior surface of the cornea in wasp sting. It might be well claimed from this that the superficial tissue of the anterior iris stroma was in the present case first changed by the toxic action of the wasp sting into a hyalin-like mass; then separated by spaces from the tissue beneath, divided into numerous small fragments, and finally thrown off into the anterior chamber. Whether the hypopyon in the anterior chamber mentioned in the literature in bee and wasp stings may arise, not at all from pus cells, but consist of this necrotic, cast off, hyalin-like iris tissue and endothelial cells, is not clear. In any case it is highly desirable in the future, to investigate microscopically the contents of the anterior chamber in cases of bee and wasp sting keratitis with hypopyon, in order to approach a solution of this problem.

"That the anatomic changes found in the iris are of a nature to explain satisfactorily the bluish discoloration of the iris observed clinically may be affirmed. The iris color among Japanese is well known to be usually brownish. That this brown color of the iris is due entirely to the richness in pigment of the iris tissue in Japanese, as opposed to the scarcity of pigment in the irides of Europeans, which are usually of bluish color, is true beyond a doubt. It is, therefore, quite intelligible that it should appear blue, like that of Europeans, when robbed of its richly pigmented anterior stroma layer, it becomes poorer in pigment. In Hilbert's case, the greenish discoloration of the iris had disappeared a week after the accident. This restoration of the normal condition in Hilbert's case is obviously not in accordance with my findings; since the iris change in my case is of an irreparable nature.

"The mydriasis which, together with the iris discoloration, presented during the whole period of observation, was one of the most striking symptoms."

The vascuoles in the pupillary sphincter may account for the former; on the other hand, it is not impossible that the nerve fibers, as well as the sphincter, are affected by the wasp's toxin, and so produce the dilatation of the pupil. The insensitive cornea may also be traced to lesions of the nerves due to toxic action.

In addition to the traumatism of the sting these predatory insects undoubtedly infect the wound with an acrid poison. Severe swelling of and pain in the lid, and sometimes of other ocular parts stung by the wasp, have been noted by ophthalmologists requiring the usual remedies for relief.

Carl Bär (*Klin. Montsbl. f. Augenheilk.*, Sept., 1913) saw a child fourteen days after it had been stung on the eye by a wasp. The seat of the sting was visible as a small white speck in the centre of a red spot downwards and outwards from the cornea. In the lower-outer part of the pupil a triangular white opacity of the lens could be seen, and there was a posterior synechia of the iris at the same point. Vision was normal, and there was no change in the fundus. The lens opacity became total and linear extraction was performed, good vision being afterwards obtained with glasses.

The writer believes that the toxin of the wasp sting acted on the lens, either directly or through disturbance of the ciliary body, but the possibility of direct injury to the lens cannot be excluded.

Wassermann's reaction. The complement-fixation reaction applied to the diagnosis of syphilis. When the blood-serum of a syphilitic patient is mixed with an extract of the liver of a still-born syphilitic child, no reaction takes place; but if the patient is not syphilitic, hemolysis occurs.

In a complement fixation test a hemolytic serum is added to another containing an antibody and the corresponding antigen. (See *Immunity* at the end of **Bacteriology of the eye**). The complement (the active hemolytic ferment) of the hemolytic serum becomes fixed, so that it is incapable of producing hemolysis.

See, also, **Luetin,** p. 7543, Vol. X as well as the heading **Syphilis** and **Tabes,** of this *Encyclopedia.*

The extreme value of this test for syphilis has been abundantly proven as time advances; it only remains to define its sphere of usefulness (especially in ophthalmology) more definitely. For this purpose the following abstracts are given:

Of the early investigations, those of Liegard and Offret (*Annales d'Oculistique,* p. 150, Vol. 148, Dec., 1912; abst. *Oph. Review,* May, 1913) in the laboratory of the Quinze-Vingts during the first half of 1912 in 167 patients suspected of syphilis are very valuable. They did the Wassermann proper with one variation of the proceeding, the Hecht-Levaditi modification, in which one utilizes the natural complement of human serum by not heating this serum. For the last month they used the Bauer-Weinberg modification of Hecht, but by control experiments they conclude that all three methods give identical results.

The patients were put into four categories: A. Probable hereditary syphilis—all those with the recognized stigmata of hereditary lues and those whose mothers had had a considerable number of miscarriages. B. Certain acquired syphilis—cases actually showing chancre, roseola, etc., or with a history of certain luetic infection. C. Probable acquired syphilis—cases with a history of a group of symptoms recalling the period of invasion of lues without the diagnosis having been made at the time of the infection. D. Doubtful syphilis—all the cases whose ocular affections could be luetic, but who did not present any extra-ocular lesion definitely luetic and who did not have any affection or any antecedent symptoms referable to the spirochæte.

The first table shows the number of + and — reactions in the different categories for the different affections—to this one has added the percentages.

Disease	A Hereditary		B Acqr'd. Cert.		C Acqr'd. Prob.		D Doubtful	
	+	—	+	—	+	—	+	—
Interstitial keratitis	23	4	1	0	5	0	12	6
Iritis	0	0	4	2	4	1	7	33
Choroiditis	0	1	1	0	0	0	1	9
Optic atrophy	0	0	2	0	2	0	3	6
Ocular palsies	0	0	1	1	2	0	6	6
Sundry affections	0	0	2	0	1	4	3	14
Percentages positive	85		78.5		73.7		30	

Under sundry affections we have 3 optic neuritis, 1 retinitis pigmentosa, 3 high myopias with macular lesions, 2 lens luxations, 2 toxic amblyopias, 1 keratitis bullosa, and 1 infection of the sympathetic type starting 15 days after a cataract operation—all negative; 1 complete cataract coming on gradually and progressing without fundus lesion in a woman of 40, 2 orbital margin periostitis, 1 eczema of lid—all positive; 3 episcleritis, 1 positive, 2 negative; 4 vitreous hemorrhages, 1 positive, 3 negative.

Of the 167 cases, 80 were positive and 87 negative, *i.e.*, 47.8 per cent. positive.

The sundry affections being too few in number to give percentages, the authors divide their cases into three groups, viz.: (1) *Interstitial keratitis*—total of old and new cases 51, of these 41 positive, *i.e.*, 80 per cent. In category A. 23 of the 27 cases were positive, *i.e.*, 85 per cent., but all the 16 active cases were positive. The 11 other, old, cases had all followed out a more or less severe mercurial treatment, but in spite of this 7 were positive, 63.6 per cent., and only 4 negative. These 4 had had at least 3 years of vigorous mercurial treatment, the infections dating back 4—5—9 years.

In another table are grouped the 18 cases where they could not find any symptom of hereditary lues, apart from the corneal lesion. In 5 cases, on the contrary, the anamnesis warranted insertion in category C. In one case the man had been treated five years before at St. Louis for secondaries.

In B. and C. all six reactions were positive, and in D. as many as 12 of the 18 cases were positive—66.6 per cent. Except in one case of 16 months' duration, that had been well treated for 15 months, the negative reactions were in recent cases—3 weeks, 6 weeks, 3 and 5 months.

(2) *Irido-choroiditis.* Sixty-three cases of uveal tract affection, 17 positive—27 per cent. Two tables are given here, first, cases with lues certain or probable, and, second, cases where nothing was found in history or clinical examination to warrant its being attributed to lues. Of the 13 in the first table 9 were positive—69 per cent.—the percentage found by Levaditi and Latapie in 1911—while the 4 negative results were in cases where lues was almost certain. None of these patients had carried out anti-luetic treatment sufficiently vigorously to modify the reaction. In the second table are included 14 cases where no evidence had been obtained as to the start of the affection, or treatment used, and where they had to be content with a rapid examination the day the blood was taken. In 50 cases 8 were positive—16 per cent. In the 42 negative cases, 4 times only had a severe

mercurial treatment been able to influence the reaction, and 24 times there had been no specific treatment.

(3) *Optic atrophy and oculo-motor paralyses.* Twenty-nine tested, 16 positive—55 per cent.

Under category B. 4 cases, 3 positive, 1 negative in a man distinctly tabetic whose primary dated back 16 years and who had been very irregularly treated for only one year. Under category C. 4 cases, all positive; under D. 21 cases, 9 positive—42 per cent. Of these 12 negative doubtful cases, 6 had had no specific treatment, 5 times no data as to medical treatment, once only had a serious mercurial treatment been used for one year.

In 14 definite tabetic cases 13 have been positive—92 per cent. The 15 other cases had no Argyll Robertson pupil, or altered knee- or Achilles-reflexes, and of these only 3 were positive—20 per cent.

They conclude that the reaction is not absolute, for assured luetic cases, treated little or not at all, may be negative, but a positive result is a strong presumption in favor of lues. Remarkable is the difference in the results obtained in interstitial keratitis and in irido-choroiditis, although the frequency of lues in the pathogeny of uveal affections has been variously estimated by different authors, *e. g.*, in iritis Manthner says 75 per cent., Chevallereau and Chaillous 39 per cent., others with Arlt think 29 per cent., while some go as low as 8 per cent. In choroiditis one finds still more divergence of opinion, many according to tubercle the preponderating rôle. Under category D. the 66 per cent. of positive results in keratitis contrasts markedly with the 16 per cent. in irido-choroiditis.

W. H. Manson, T. J. Mackie and H. E. Smith (*British Med. Jour.*, Feb. 20, 1915) have furnished a report on the examination of 250 ophthalmic cases as follows: In the tertiary and latent stages of syphilis, only 75 per cent. and 50 per cent. respectively, yield a positive result. In interstitial keratitis, the reaction was positive in 88.8 per cent. In strumous keratitis, the results were negative in all. In iritis and iridocylitis, these cases were obtained in two series: twenty-two in the first group gave twelve positive and ten negative results. In the second group of twenty-eight cases, fifteen were positive, twelve negative, and one doubtful. Three cases of cyclitis, uncomplicated, were negative. In choroiditis, of twenty-six cases, five gave positive and twenty negative results, while one was doubtful. Four cases of sympathetic ophthalmitis gave negative results, as also did three cases of retinitis pigmentosa. Five cases of retinal detachment gave negative results. In inflammation of the optic nerve and retina, only five positive cases were obtained out of a total of fourteen. In optic atrophy, of twenty-one cases, 57 per cent. gave positive results, and it is interesting to note that ten diagnosed as primary optic atrophy were all positive. The thirteen cases of paralysis of the ocular muscles gave seven positive results, of which four were in paralysis of the third nerve. All six negative results were in paralysis of the sixth nerve. One case of dacryocystitis out of three gave a positive reaction. Six cases of myopia with choroiditis were examined. Two gave a positive reaction. Four cases of glaucoma were examined, with one positive result. It is interesting to note that out of the total number of cases of various diseases examined, 50 per cent. gave a positive reaction.

That the value of the Wassermann reaction (which after all is a test for the presence of the *treponema pallida,* its toxins or its organic compounds) depends upon the skill and efficiency of the laboratory worker is brought out in the essay of A. L. Fönss (*Ugeskrift for Laeger*, p. 1737, 1915; abst. from *The Medical Review*, January, 1916). The writer says that the value of Wassermann's reaction is great, but is apt to be slavishly and foolishly relied on to the exclusion of other methods of diagnosis. This has gone so far that some men dare not diagnose syphilis when the reaction is negative. It is not realized that *Wassermann's reaction is merely an auxiliary to the diagnosis of syphilis*, which must ultimately stand or fall by the clinical examination. The *technique* of the reaction is so complicated that it requires great skill and practice. In Denmark it is carried out exclusively in the State Serum Institute, and thus its exploitation in small uncontrolled private laboratories is avoided. In Germany, on the other hand, this test is made not only in innumerable university and hospital laboratories, but even in private practice. It is, therefore, not surprising that specimens of a patient's blood, sent at the same time for examination to various quarters, have given conflicting reactions. Thus, Frudenthal sent specimens of the same blood to four institutes in Berlin. In two the reaction was found to be negative, in a third it was doubtful, and in a fourth it was markedly positive.

It may be said, however, that a *positive Wassermann reaction* in a case of latent syphilis is important, for it is the best proof that the patient is not yet cured. A positive reaction is of great value when the diagnosis of syphilis is uncertain; but although it almost certainly indicates syphilis, it does not give the site of the disease. A negative reaction, and even a series of negative reactions, are almost valueless in the diagnosis of syphilis, particularly when the patient has recently been treated, and when the disease is latent. But even when the disease has not been treated a negative reaction is not uncommon. Both in treated and untreated cases the reaction occasionally fluctuates from positive to negative, with only a few days' or weeks' interval. It is, therefore, advisable to repeat the reaction several times in most cases.

Finally, it is a golden rule to rely on the clinical diagnosis of typical syphilis, however often Wassermann's reaction is negative.

J. A. Kolmer (*Am. Journ. Syphilis,* Oct., 1919) and others detail some sixteen methods of preserving complement serum for the Wassermann reaction. Of these the use of sodium chlorid at a low temperature yielded the best results. When complement is required in dilution of 1:10, the methods of Thompson and Neill are satisfactory for preserving guinea-pig complement for a period of two weeks, provided the serum is kept at a low temperature and preferably not above 4 C. When complement is required in dilution of 1:20 the addition of 0.17 gm. sodium chlorid to each cubic centimeter of serum and keeping at a low temperature preserves the complement for about three weeks.

Sanitary Waste Receptacle.

Waste receptacles. These useful adjuncts of operating and dressing rooms (see **Hospital**) are worthy of consideration by the ophthalmic surgeon. One of the best is depicted in the text.

Watch-glass protector. Buller's shield. See p. 1336, Vol. II of this *Encyclopedia*.

Water. Aqua fontana. Aqua pura. Aqua destillata. Spring water. In a state of purity, at ordinary temperature, water is a clear, transparent liquid, perfectly neutral in its reaction, and devoid of taste or smell. By a process of distillation and condensation it is possible to obtain a fairly pure water. Its chemical constitution, indicated by the formula H_2O (molecular weight, 18.016) is 2.016 parts of hydrogen to 16,000 parts of oxygen by weight, or two volumes of hydrogen to one volume of oxygen, which upon combustion form by their combination two volumes of water-vapor. The specific density of water at 4° C. is taken as the standard, and is reckoned equal to unity, or for some technological purposes as 1000. Water is used in the metric system as the means of connecting the measures of length and those of mass: a cubic decimeter measures a liter, and a liter of water at 4° weighs a kilogram. Similarly the gallon is ten avoirdupois pounds of water.

Water dissolves a great many substances, forming aqueous solutions. Its solvent powers for solids and liquids are in general increased by heat, while those for gases are diminished. In some cases there is heat evolved when the gases dissolve. Some liquids dissolve in water by a process of interdiffusion; and salts dissolve each in its own proportion, which varies with the temperature. Heat is often evolved by the act of solution if there be chemical combination between the salt and the water with formation of *hydrates;* but if there be no such union, then the absorption of heat in liquefying the salt results in cooling.—*(Standard Encyclopedia.)*

Ordinary spring water generally contains carbonic dioxide in solution, so that it dissolves many calcic and magnesic salts from the soil. Such water precipitates soap and, hence, is called hard water. Rain water and snow water are generally free of soil contaminations and are termed soft water. River water contains little carbon dioxide and is generally soft.

Water for use in ophthalmic therapy should, as a rule, be distilled and sterile.

One must not forget the employment of water as a topical application apart from its use as a carrier of heat and cold. The rule that pure water in douches, irrigations or sprays is not a proper fluid, or is less irritant than normal salt, one per cent. boric acid, or other bland solution for flushing or cleansing mucous membranes, to some extent applies to the conjunctiva. Yet tepid (100° F.), sterile douches of distilled water act well in washing out the sac and are most soothing to the eye, particularly in the presence of mucus, pus or toxins. It does not appear, when judiciously used in an undine (q. v.), with a medicine dropper or in a small irrigator, to increase the muco-purulent secretion.

Thompson claims that in prescribing collyria filtered water is better as a diluent than distilled water since the latter acts injuriously on epithelial cells.

J. A. Lippincott applies hot water (150° F.) drop by drop to the cornea in ulcer of that organ. This acts both as a stimulant and antiseptic and is also employed as a satisfactory remedy by many ophthalmologists.

See, also, **Hydropathy,** p. 6081, Vol. IX; **Mineral waters,** p. 7831, Vol. X; as well as **Boiling water,** p. 1243, Vol. II of this *Encyclopedia.*

Water bags. WATER BOTTLES. These convenient means of reducing or increasing the temperature of the ocular area afford one of the most cleanly means of applying dry heat or cold and of securing rubefaction. When covered with flannel or wrapped in cloth they retain the heat much longer and are much less liable to produce burns. The possibility of this accident should always be kept in mind; the bag should not be used when it is too hot to be borne for half a minute against the cheek.

O. A. Griffin (*Trans. Am. Acad. of Oph.*, p. 140, 1906) uses in aggravated and prolonged acute inflammatory diseases of the eye a small rubber bag through which either hot or cold water can be syphoned. To make the application more effective (by a retention of the applied temperature) a double layer of moistened gauze, about two inches square, is first placed over the affected eye and the water bag then put into position and retained in place, if desired, by means of a tape or string. Single or double bags are used, depending upon whether one or both eyes are affected. To retard the discharge of water and thus prolong the duration of application, and also to produce a distension of the bag, a tiny opening is made at the end of the discharging tube by inserting a bit of hard rubber tubing which contains a minute passage through which the water escapes. The arrangement is completed by placing two pitchers of like capacity at the proper height to produce a slow and steady flow of water from the upper to the lower vessel. When the upper one is nearly empty, it is only necessary to pinch the tubing or elevate the discharging end and pour the water from the lower into the upper pitcher to keep the apparatus running properly. The stream will flow from thirty to sixty minutes, depending upon the relative height of the pitchers and the size of opening in the discharging tube. By timing the process, the attendant may know exactly when to change the water, and the compress may be applied steadily and indefinitely without disturbing the eye or the patient, which is very important, especially when the patient is sleeping and rest is essential.

If cold compresses are desired pieces of ice may be added to the water, and to retain the rubber tubing in the upper vessel a foot of glass tubing is inserted into the rubber one, which also prevents collapse of the tubing should the ice press upon it.

If hot applications are indicated heated water is used instead and kept at a uniform degree by occasional additions of hot water. In his experience, unless pain demands a continuous application, the most satisfactory results are secured when the compress is employed intermittently, fifteen or thirty minutes elapsing between applications.

After the apparatus is properly arranged, the appliances for which may be obtained in any ordinary home, it requires little or no attention and, in the writer's opinion, is the most rational method of employing heat or cold in the treatment of acute inflammatory disorders of the eye, inasmuch as the temperature is uniform, the water bag is light and conforms to the surface beneath, the compress is applied directly to the area desired, the patient is not chilled or drenched by escaping water and the application may be used indefinitely without disturbing the patient.

Water, Bitter-almond. See **Aqua amygdalæ amaræ,** p. 542, Vol. I of this *Encyclopedia.*

Water blindness. See **Glaring**; as well as **Blindness, Water,** p. 1197, Vol. II of this *Encyclopedia.*

Water, Boiling. See **Boiling water.**

Water-caltrops. *Trapa natans.* The juice of the water-caltrops was employed in ancient Greco-Roman times as an ingredient of various ophthalmic prescriptions. It seems to have been regarded, however, merely as an adjuvant to more active substances.—(T. H. S.)

Water, Camphor. See **Aqua camphoræ,** p. 542, Vol. I of this *Encyclopedia.*

Water, Cherry-laurel. See **Aqua laurocerasi,** p. 543, Vol. I of this *Encyclopedia.*

Water, Chlorine. AQUA CHLORATA. AQUA CHLORI. See **Chlorine water,** p. 2064, Vol. III of this *Encyclopedia.*

Water, Elderflower. See **Sambucus.**

Water-flea. A popular name for minute aquatic Crustaceans such as Daphnia among Cladocera, Cypris among Ostracoda, and Cyclops among Copepoda. The common *Daphnia pulex*, abundant in fresh water, is a good representative. The body is enclosed in a bivalve shell; there is a *large single eye;* a pair of large antennæ are used as swimming organs.

Watering of the eyes. A vulgar name for epiphora or lachrymation.

Water, Lead. See **Lead water,** p. 7028, Vol. IX of this *Encyclopedia.*

Water-lens. A lens in which water is one of the refracting media.

Water-poise. A hydrometer.

Water prism. A prism in which water is one of the refracting media. This device is a pentalateral of glass filled with water.

Water, Rose. See **Rose.**

Waters, Eye. See **Collyrium,** p. 2337, Vol. IV of this *Encyclopedia.*

Water, Spring. See **Water.**

Water-telescope. (a) An optical instrument used for examining objects immersed at some depth under water. (b) A telescope, of which the tube is filled with water.

Wathen, Jonathan. A celebrated London surgeon and ophthalmologist of the 18th century, whose exact life dates can no longer be ascertained. In addition to works on the ear and on venereal diseases, he wrote the following: 1. *A New and Easy Method of Applying a Tube for the Cure of Fistula Lacrymalis.* (London, 1781; 2d ed., 1782.) 2. *A Dissertation on the Theory and Cure of the Cataract, in which the Practice of Extraction is Supported and that Operation in Its Present Improved State is Particularly Described.* (London, 1785.)—(T. H. S.)

Watson, Alexander. (Known in later life as Watson-Wemyss.) A distinguished Scotch ophthalmologist, medico-jurisprudentist, and author of the first compendium of ophthalmology in the English language. Born in 1799, he settled in Edinburgh, became surgeon to the Royal Infirmary and the Royal Eye Infirmary, as well as F. R. C. S., Edin. In 1846 he inherited the estates of Denbrae in Fife, retired from practice, and was thenceforth known as Watson-Wemyss. In 1848 he was decorated by the Czar of Russia for his work in legal medicine. He died in 1879. Dr. John Watson-Wemyss, of Edinburgh, is his son. Watson's most important writings are as follows: 1. *A Compendium of the Diseases of the Human Eye.* (1822, 2d ed., 1828; 3d ed., 1830; 4th ed., 1839.) 2. Observations on the Effects of Inflammation and Injuries upon the Humors of the Eyes. (*Ed. M. and S. Jour.,* 1826, No. 89, pp. 260-269.) 3. Observations on Chronic Iritis. (*Edinb. Med.-Chir. Trans.,* 1826, II.) 4. *Anatomical Description of the Human Eye.* (Edinb. 1828.) 5. On the Pathology of the Eye. (*Ed. M. and S. Jour.,* Jan., 1831, pp. 73-81.) 6. Report of the Edinburgh Eye Infirmary. (*Ed. M. and S. Jour.,* No. 122, Jan., 1835, pp. 126-136.) 7. *A Medico-Legal Treatisé on Homicide by External Violence.* (London, 1837.) 8. On Inflammation of the Membrane of the Aqueous Humor of the Eye. (*Ed. M. and S. Jour.*, July, 1845, pp. 98-105.) 9. Historical and Critical Remarks on the Operation for the Cure of Cataract. (*Ibid.*, Oct., 1845, pp. 389-400.)—(T. H. S.)

Watson, Spencer. A well-known London ophthalmologist and otologist. Born about 1836, the son of a London physician, he became in 1857 M. R. C. S., and, in 1862, F. R. C. S. He was at various times surgeon to the Central London Ophthalmic Hospital, surgeon to the South London Ophthalmic Hospital, instructor in ophthalmology at the Zenana and Female Medical Mission, etc. He was a charter member of the Ophthalmological Society. In his later years he was totally blind, after, it is said, an operation for cataract. He died at 44 Chepstow Place, London, W., in 1906, aged about 70 years.

Among his more important writings are: 1. Subacute Glaucoma Successfully Treated by Iridectomy. (*Med. Times and Gaz.*, 1863.) 2. *On Keratitis.* (1864.) 3. Syphilitic Ulcers of the Face. (*Lancet,* 1867.) 4. Case of Intra-orbital Dermoid Cyst. (*Ib.*, 1872.) 5. *Diseases of the Nose and Accessory Cavities.* (1875.) 6. *Eyeball-tension, its Effects on the Sight, and its Treatment.* (1879.)—(T. H. S.)

Wauchope, Robert. Often called, "The Blind Archbishop." He was born blind, but became Archbishop of Armagh in 1543.—(T. H. S.)

Wave frequency. The number of waves passing or reaching a point in unit time.

Wave-length. The distance between any two particles of similar phase in the path of a (sound or light) wave. See **Light.**

Wave-line. WAVE-PATH. The line along which any point in a wave front is propagated; a ray.

Wave propagation of light. See **Light.**

Wave-surface. A surface coinciding with an advancing wave front.

Wave theory. UNDULATORY THEORY. See **Light.**

Wax. WHITE WAX. YELLOW WAX. CERA, U. S. CERA CITRINA.

Wax is the name given to some animal and vegetable substances, and even to one or two mineral bodies, which more or less resemble bees-wax both in their appearance and in their physical properties. True waxes contain no glycerin, but are combinations of fatty acids with certain solid monatomic alcohols. Waxes may be divided into liquid and solid waxes. Two liquid waxes are known, sperm oil and arctic sperm oil (Bottlenose oil), which are obtained from the blubber of the sperm whale, and from the head cavities of those whales which yield spermaceti. Of solid waxes, carnauba is a vegetable wax. The most important of animal waxes are wool-wax (the main constituent of the natural wool fat covering the hair of sheep), bees-wax, spermaceti, and insect wax, or Chinese wax.—(*Standard Encyclopedia.*)

The wax of the pharmacopeia is a solid, yellow or white substance obtained from the honey-comb of the bee. White wax is merely yellow wax bleached by exposure to light and air or (improperly) by means of chlorine. There are also numerous vegetable waxes. Wax is mostly employed in making cerates and is an adjunct to salves. An example is: Hydrargyri oxidi flav., 0.2 (gr. iij); Ceræ alb., 1.5 (gr. xxii). Misce et fiat unguentum.

Web. Pin and web. A folk-lore expression for a condition of the eye (probably pterygium) which is described as a "darkening speck on the cornea with a film spreading in fan shape from the cornea."

Webb, Thomas Law. A well-known English ophthalmologist. Born in 1847 (8?), he received the M. R. C. S. (Eng.) in 1870, the L. R. C. P. (Lond.) in 1872, the M. B., B. Ch. (Birm.) in 1901, and the M. D. (Birm.) in 1903. He was honorary pathologist to the Salop Infirmary and to the Eye, Ear, and Throat Hospital, at Shrewsbury, at the time of his death in 1911.—(T. H. S.)

Weber, Adolf. A celebrated German ophthalmologist, inventor of numerous instruments in use at the present day, and one of the greatest operators of all time. Born at Giessen June 19, 1829, he studied at Giessen and Berlin, at the latter institution receiving his degree in 1854. While at Berlin, he studied ophthalmology with von Graefe—who, at his death, left all his instruments to Weber. In the year of his graduation, Weber fought in the Schleswig-Holstein War. The year following, however, he settled in Darmstadt both as general practitioner and as ophthalmologist. From 1870 until his death, he restricted his practise to ophthalmology. In 1878 he was made Privy Medical Councillor. He invented the suction method for the treatment of detachment of the retina. He also invented a number of plastic operations, as well as operations on the lachrymal apparatus. He died July 17, 1915, aged 86.

This celebrated operator's instruments, so well known to every ophthalmic surgeon, are duly depicted and described under proper captions in this *Encyclopedia*. They are chiefly Weber's (a) canaliculus knife, (b) graduated dilator, (c) hard rubber spoon, (d) speculum, and (e) angular keratome.

Some of Weber's more important ophthalmologic writings are as follows: 1. Ueber the Ophthalmoskopische Erkennung von Niveaudifferenzen des Augenhintergrundes. (Graefe's *Archiv*, II.) 2. Ueber Anatomie und Physiologie des Thränenableitungsapparates. (Zehender's *Klin. Monatsbl.*, 1863.) 3. Ueber Corelysis. (Graefe's *Archiv,* VII.) 4. Zur Behandl. der Thränenschlauchstricturen. (*Ib.,* VIII.) 5. Ueber Nekrotische Hornhautabscesse. (*Ib.,* VIII.) 6. Die Normale Linsenentbindung. (*Ib.,* XIII.) 7. Uever Calabar und seine Therapeutische Verwendung. (*Ib.,* XXII.) 8. Die Ursache des Glaucoms. (*Ib.,* XXIII.) 9. Ueber das Alkaloid der Fabae Calabaricae. (*Centralbl. f. d. Med. Wissensch.,* 1876.) 10. Ueber Cocain. (Zehender's *Klin. Monatsbl.,* 1884.)—(T. H. S.)

Weber, Moritz Ignatz. A well-known German anatomist, who paid considerable attention to the anatomy of the eye. Born at Landshut, July 10, 1795, he became in 1830 at Bonn professor of comparative and pathological anatomy. He was also privy medical councillor when he died, July 22, 1875.

His only ophthalmologic writing is "*Ueber das Strahlenblättchen im Menschlichen Auge*" (Bonn, 1827; 1 plate).—(T. H. S.)

Weber's chromoptometer. See **Chromoptometer, Weber's,** p. 2207, Vol. III of this *Encyclopedia.*

Weber's law. The increase of stimulus required to be perceptible (as an increase) bears a constant ratio to the total stimulus. Thus, if one can just see a difference of one per cent. in a weak light it will require the same ratio per cent. in a strong light before it can be perceived.

Weber's symptom. WEBER'S SIGN. WEBER'S SYNDROME. This phenomenon is mentioned under several of the above captions. A good account of the symptom-complex is given by G. B. Hassin (*Journ. Am. Med. Assocn.,* p. 2169, Dec. 29, 1917) who reports a case in which it was found. The writer says that, *clinically,* this syndrome means *a complete or partial paralysis of the oculomotor nerve combined with a contralateral hemiplegia.* Pathologically, it signifies some lesion of one of the cerebral peduncles (the crus cerebri). The practical value of this syndrome lies in the possibility of precisely locating a brain lesion, since the presence of Weber's syndrome is a sure evidence of involvement of a portion of the brain—the peduncular region—that so far has been absolutely inaccessible to operative interference.

Weber's syndrome will be complete and pronounced when that part of the peduncle is involved which is adjacent to the oculomotor nerve, that is, the inner portion. Otherwise, the oculomotor nerve may be spared, and then, in spite of the presence of a peduncular lesion, the syndrome will be lacking and will have no value as a sign of localization. As a rule, however, the peduncular lesion results in both oculomotor and pyramidal tract involvement. It was described long before Weber's day. Thus, Mohr minutely reports this syndrome twenty-three years before Weber, and Green mentions it eleven years before Weber. In 1859, that is to say, four years before Weber's paper was published, Gubler, in speaking of paralysis alternans, describes a case of Luton in which a hemiplegia of the left side was associated with a right third nerve paralysis, as the result of a softening of the right cerebral peduncle. Yet none of these authors give so precise and complete a description as Weber, who in 1863 pointed out the anatomic, clinical and pathologic characteristics of a peduncular lesion, which Charcot in 1891 proposed to call the Weber syndrome. Weber's contribution was followed by a number of reports, some of which were purely clinical. In other words, they had not been substantiated by necropsies, as in Jellifle's three cases and Zozin's case. Some of these reports represented a somewhat modified clinical picture.

To the modified type of Weber's syndrome belongs the so-called *Benedikt syndrome* in which the paralyzed side shows a tremor resembling that of paralysis agitans, chorea or athetosis and in which the lesion was found to be not so extensive in the peduncles as in the so-called tegmentum, the region above the latter.

The study of the few pathologic reports pertaining to Weber's syndrome shows that this can be caused by softening, hemorrhages, posthemorrhagic cysts, tumors, as tubercles, gliomas, sarcomas, new growths not identified, hydatic cysts, abscesses, and a revolver bullet. Tumors were by far the most frequent cause of the peduncular lesion, especially tubercules and gliomas.

Pelfort (*Revista méd. del Uraguay,* Feb., 1919; abst., *Journ. Am. Med. Assocn.,* Nov. 12, 1919) reports a case in a boy of 4 presenting total paralysis of the left side with paralysis of the oculomotor nerves on the other side and positive tuberculin skin reaction. The spinal fluid seemed normal, the Wassermann reaction was negative and there were no symptoms suggesting involvement of the cerebellum.

Web-eye. A folk-lore expression signifying an eye with a film spreading over it—with, probably, pterygium.

Wecker, Louis de. A celebrated Parisian ophthalmologist, of German birth and parentage, inventor of de Wecker's pince-ciseaux (for the division of after-cataract) and of de Wecker's double strabismus hook for advancement of the recti tendons. Born Sept. 29, 1832, at Frankfort on the Main, he studied at Würzburg, Berlin, Vienna and Paris. He first, in 1855, received his medical degree at Würzburg, and in 1861 received the same degree (*ad eundum*) in Paris. The teachers who chiefly influenced him were Arlt, Desmarres, von Graefe, Jaeger and Sichel. For a time he practised as general physician in France, and then in Russia; but, in 1862, he settled in Paris as ophthalmologist exclusively. He had an enormous practice and

Louis (de) Wecker.

was known in every portion of the civilized world. In addition to the inventions mentioned above, de Wecker devised sclerotomy as a cure for glaucoma, and introduced the tattooing of leucomata both for visual and for cosmetic purposes.

His numerous instruments and ophthalmic devices will be found fully described and depicted under their proper heads in this *Encyclopedia.*

Perhaps, however, de Wecker's claim to remembrance is quite as securely based on his literary performances, as on his operative devices and instruments. Thus, in the following bibliography, the first of the titles is that of a work which was very long regarded as an absolute masterpiece of scientific accuracy as well as of literary style. Even to the present decade it has been very much referred to; and not a composition in the list but contained at least one point possessed of more or less enduring value. 1. *Traité des Maladies des Yeux.* (Paris, 1863; 2d ed., 1869; 3d ed., 1880.) 2. *Traité des Maladies du Fond de l'Oeil.* (Paris, 1870.) 3. Tatouage de la Cornée. (With E. von Jaeger, *L'Union Méd.*, 1870.) 4. Astigmatismus und Schädelbildung. (Zehender's *Klin. Monatsbl.*, 1870.) 5. Die Sclerotomie als Glaucom-operation. (*Ib.*, 1871.) 6. De la Greffe Darmique en Chirurgie Oculaire. (*Annal. d'Ocul.*, LXVIII.) 7. Le Trépan Oculaire et son Application. (*Ib.*) 8. De l'Ablation du Staphylome Total de Cornée. (*Ibid.*, LXIX.) 9. Sur l'Incision du Nerf Optique dans Certains Cas de Nevro-Rétinite. (*Congrès de Londres*, 1873.) 10. De l'Iridotomie. (*Annal. d'Ocul.*, LXX.) 11. Sur un Nouveau Procédè Operatoire de la Cataracte. (*Ib.*, LXXIII.) 12. Die Erkrankungen des Uvealtractus und des Glaskörpers. (Graefe u. Saemisch's *Handb. der Ges. Augenheilk.*, 1876, IV.) 13. Glaucom und Augendrainage. (v. Graefe's *Archiv*, XXII.) 14. *Thèrapie Oculaire.* (Paris, 1878.) 15. Chirurgie Oculaire. (*Ib.*, 1879.) 16. L'Egongation des Nerfs Applique a la Chirurgie Oculaire. (*Annal. d'Ocul.*, LXXXV.) 17. *Précis d'Ophthalmoscopie Clinique.* (Paris, 1881.) 18. L'Ophthalmie Purulente Factiee Produite au Moyen du Jequirity ou Liane à Reglise (*Ann. d'Ocul.*, LXXXVIII.) 19. La Cicatrice à Filtration. (*Ib.*, LXXXVII.) 20. *Traité Complet d'Ophthalmologie.* (Paris, 1883 and 1884.) 21. Les Indications de l'Extraction Simple. (*Ib.*, 1885.) 22. La Cicatrisotomie ou Oulétomie. (*Ann. d'Ocul.*, XCIII.)

de Wecker died at Paris, Jan. 24, 1906, in the 74th year of his age. —(T. H. S.)

Wedge compensator. A pair of quartz wedges used in some forms of polarimeters for determining the polarized condition of a beam of light.

Wedge-isolation operation. A procedure for the relief of glaucoma. See p. 5521, Vol. VII of this *Encyclopedia.*

Wedge-micrometer. A graduated wedge used to measure the separation of two objects between which it is intruded.

Wedge-photometer. A graduated wedge of dark neutral-tinted glass.

Week's bacillus. See p. 805, Vol. II of this *Encyclopedia*.

Weigert's stain. See p. 6911, Vol. IX of this *Encyclopedia*.

Weil's disease. FIEDLER'S DISEASE. ACUTE FEBRILE JAUNDICE. This is an acute infectious disease characterized by icterus, muscular pain and fever, with enlargement of the spleen and liver. The acute symptoms persist for a couple of weeks, after which there is complete recovery. The disease is caused by a spirochete.

Koshichi (*Oph. Year-Book*, p. 360, 1913) says Weil's disease is not uncommon in the southern part of Japan. There were in cases he saw hemorrhagic foci in the ocular conjunctiva, the muscles, the optic nerve, the iris, the ciliary body and the choroid. The ciliary body showed round-cell infiltration, which also extended into the vitreous and anterior chamber.

Weintz, Charles Henry. An ophthalmologist of Cincinnati, O. Born in 1870, he received the medical degree at the Miami Medical College, Cincinnati, in 1909. He was, as lieutenant, assistant to the chief of the nose and throat department of the base hospital at Chillicothe, O., Major C. R. Holmes. Weintz was a genial, industrious officer, highly esteemed by his associates. He died at Camp Sherman, Oct. 14, 1918, of pneumonia.—(T. H. S.)

Weir, Fred Hamilton. A well-known ophthalmologist of Chicago, later of New York City, and, later still, of Portland, Oregon. Born at La Porte, Indiana, Sept. 11, 1864, son of the Honorable Morgan H. and Henrietta E. Teeple Weir, he received the degree of Bachelor of Arts, and in 1885 that of Doctor in Medicine at the University of Michigan. In 1893 he received, in addition, and at the same institution, the degrees of Mechanical Engineer and Doctor of Philosophy. He then proceeded to study the eye, ear, nose and throat at London, Berlin, and Vienna.

Returning to America, Dr. Weir was made Professor of the eye, ear, nose and throat at the University of Michigan, practising for a time in Chicago, then in New York City. While in this place, he married Miss Maude Marston.

In 1903, because of ill health, he removed to Portland, Oregon. Early in 1913, because of continued sickness, he took a trip to Honolulu, and, later in the same year, repeated the voyage. Both the trips appeared to have been of benefit, but, in June, 1914, he suffered a severe fall, and was never very well thereafter. While spend-ing Thanksgiving Day, 1914, with Mr. and Mrs. Haines, in Portland, he was stricken with the final blow, but did not pass away until Jan. 2, 1915. He was survived by the widow and by a brother, Ellsworth E. Weir, of La Porte, Indiana. The remains were cremated

Dr. Weir was a slender man of middle height, smooth faced, of very dark complexion and with hazel eyes and almost jet black hair. He was gravely courteous to strangers, but to his intimate acquaintances and friends was brisk and even rollicking, in fact the best of company. His hobbies were music, and mechanics. To him is attributed one of the first models of the submarine, which, however, and most unfortunately, was destroyed by a fire which, in addition, almost cost the Doctor his life. Before this loss could be repaired, the idea of the model had occurred to other inventors, and the Doctor's opportunity had been irretrievably lost. Weir also designed a number of drawing and surgical instruments. He founded, and for four years directed, the college orchestra at the University of Michigan, and was a charter member of the Manuscript Music Society of America. His last composition, written in Honolulu, was the "Hawaiian Band March," and was dedicated to Captain Henri Berger, for forty years leader of the Royal Hawaiian Band. In his beautiful home at Weir Crest ranch, near Connell Station, in Washington County, the hospitable Doctor and his charming wife entertained most abundantly and almost royally. In this house was a fully equipped machine shop, a draftsman's shop and a musician's studio—always points of interest to guests.

To close this sketch the following characteristic anecdote is added from the pen of Mr. Dilworth Choate, who was a member of the editorial staff of the *New York World* in the early 90's: "The incident that stands out strongest in my memory of Dr. Weir (who at the time was one of the leading oculists in the city—having been called in conference when the late Joseph Pulitzer, owner of the '*World*,' was stricken with blindness) was one in which he was the means of saving a dog's eyesight.

"Dr. Robert Milbank, an eminent surgeon connected with Bellevue Hospital, was a great hunter. He used to go every year to Currituck Bay, Maryland, for ducks. A pure-white Chesapeake retriever was his companion on these trips. The dog was valued at perhaps $1,500.00, but so far as Dr. Milbank and his family was concerned it had no money value.

"One day in New York the dog ran a sliver in one of his eyes. Only a prompt and skillful operation could save its sight. Dr. Milbank called upon a prominent oculist and told him the trouble, asking him if he would operate. The oculist indignantly refused, telling Dr. Milbank to take the dog to a veterinarian.

"Dr. Milbank thought of Dr. Weir and called him up. Dr. Weir told him to bring the dog to his office just as soon as possible.

"The operation was successful. I wrote the story for the *World*. The other papers printed it, too, and Dr. Weir received much favorable publicity.

"This was typical of Dr. Weir. He had a regardful care for everyone, man or beast, and his death is a loss to the cause of humanity."—(T. H. S.)

Weiss reflex. See p. 10920, Vol. XIV of this *Encyclopedia*.

Randall (*Oph. Year-Book*, p. 87, 1909) again calls attention to the reflex seen to the nasal side of the disk, with which it is concentric, as a sign of myopia that is increasing. He reports two cases: one of a boy who, at the age of 10, had hyperopia .50 D., with this reflex; at 15 he had myopia of 1.5 D.; his parents were hyperopic. The other case was a boy of 10, whose eyes were hyperopic, but who belonged to a myopic family. Randall thinks the reflex pathologic, rather than a mere anomaly, and considers it more characteristic than conus or other signs of distension at the posterior pole.

Weisse Augenhaut. (G.) Sclerotic.

Weicher Staar. (G.) Soft cataract.

Welcker, Hermann. A celebrated German anatomist and anthropologist, who devoted considerable attention to the eye and to optics. Born Apr. 8, 1822, at Giessen, he there received his medical degree in 1851, and there two became prosector. In 1859 he was called as prosector and extraordinarius in anatomy to Halle, where in 1866 he became ordinarius. He died at Winterstein, Sept. 12, 1897.

Welcker's chief ophthalmologic writing was entitled *"Ueber Irradiation und Einige Andere Erscheinungen des Sehens"* (Giessen, 1852).—(T. H. S.)

Welder's amblyopia. Eye diseases of welder's. See **Dazzling**, p. 3778, Vol. V; as well as **Eclipse amblyopia.** See, also, **Glassblower's cataract**; and **Puddlers, Eye diseases of,** in this *Encyclopedia.*

In the use of the oxy-acetylene torch it is very necessary to protect the eyes from the harmful rays of the flame. The United States Bureau of Standards (see, also, *Bull. No. 11, Fed. Board for Vocational Education,* p. 65, 1919) makes the following recommendations: The oxy-acetylene welder (the same is true of the cutter) is liable to temporary or permanent injury because of the action of ultraviolet, visible, or infra-red radiations on the eyes. This danger may be eliminated by the use of suitable goggles. Dark-yellow or brown glasses containing iron, such as the Noviweld glasses (see p. 8384, Vol. XI of this *Encyclopedia*) at present on the market, seem to be safest. A shade should be used which is dark enough to eliminate all discomfort and glare from the visible radiations. Such a shade will absorb all the ultra-violet and most of the infra-red.

There is also a danger to the face, neck, hands, and legs of the operator from molten metal, sparks, and flame. Drops of molten metal may enter the shoe at the top or even at an eyelet hole or other exposed place and burn very severely. Such a burn is very slow to heal and very liable to infection.

Welder's glass, Wilson's. See **Wilson's welder's glass.**

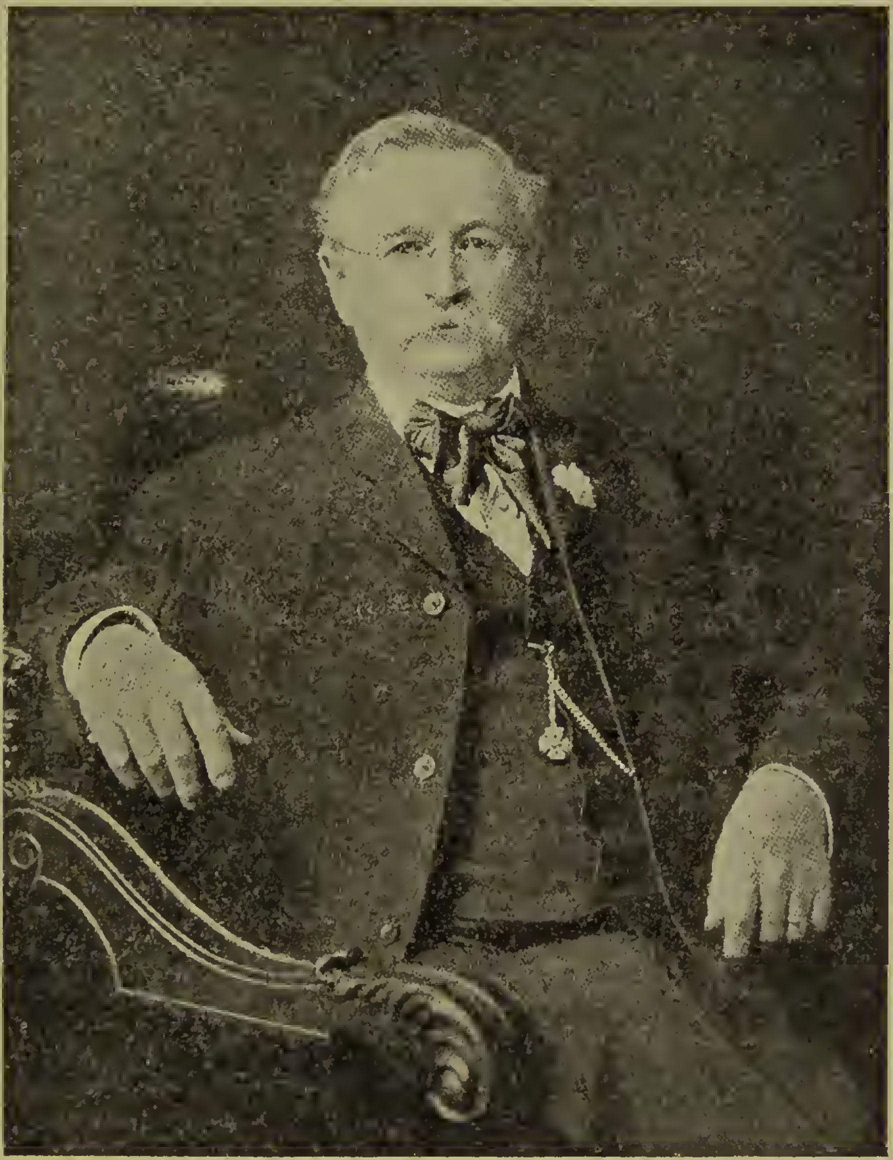
Wellenlänge. (G.) Wave length.

Weller, Karl Heinrich. A distinguished German ophthalmologist, author of an ophthalmologic text-book much in use in Germany and elsewhere for many years. Born at Halle, Oct. 22, 1794, he received his medical degree in 1817 at the University in that place. Settling in Dresden, he lived and practised there until his death, Oct. 11, 1854.

His ophthalmologic writings are as follows: 1. *Die Krankheiten des Menschlichen Auges.* (Berlin, 1819; 4th ed., 1831; Eng. ed., 1821; Russian, 1823; French, 1828.) 2. *Ueber Künstl. Pupillen und eine Besondere Methode, dieselben zu Fertigen.* (Berlin, 1821.) 3. *Diätätik für Gesunde und Schwache Augen; für Arzte und Gebildete Nichtärzte.* (Berlin, 1821.) 4. *Icones Oph. seu Selecta circa Morbos Humani Oculi.* (Fascic. I. Leipsic, 1825. All that was issued.)—(T. H. S.)

Wells, George Washington. The chief figure in the upbuilding of the American Optical Company. He was born in Woodstock, Connecticut, April 15, 1846, son of John Ward, and Mary Cheney Wells. A grandfather and a great-gandfather were Revolutionary soldiers, and the stock was entirely English. At the age of four the subject of this sketch fell and broke his ankle. For ten years thereafter he walked only with the aid of crutches. For two years he attended Woodstock Academy, and then for a short period taught school at Red Bank, Navesink Highlands, N. J. Coming to Southbridge, Mass., with fifty dollars which he had made teaching school, and an equal sum which had been left him by his mother, he became an apprentice to the optical business of R. H. Cole & Co. Later, he entered the machine shop of the Hamilton Woollen Co., at Globe Village, where he remained a short time. He then returned (on his own account) to the optical business, which he followed to the end of his days unremittingly, with the exception of a few months on the Pacific slope in 1867.

In 1869, when the firm of R. H. Cole & Co. and H. C. Ammidown & Co. were consolidated under the title of the American Optical Co., Wells was made the secretary of the organization. In 1879 he was elected treasurer, in 1881 president, holding both these offices till 1908, when Albert B. Wells, his son, was chosen treasurer.



George Washington Wells.

It was chiefly owing to the efforts of the subject of this sketch that the American Optical Co. arose to its present world-wide importance —a fact due not only to Mr. Wells's great executive ability, but quite as much to his practical, ingenious inventiveness. He founded (to mention a very few matters) standardized optical goods with absolutely interchangeable parts. He invented the method of tapering temples by means of eccentric rolls; also the first automatic lens-cutting machine, the peening or riveting together of joints to be soldered, the first machine for jumping bridges to absolutely correct size, and the first automatic machine for the making of spectacle end-pieces. He also invented the well-known Wells eyeglass guard. He also discovered the wonderful cutting properties of the Cragleith stone for edging machinery. In fact, over 30 optical patents were issued in his name.

Wells married, Sept. 27, 1869, at Southbridge, Mass., Miss Mary Elizabeth McGregory. To the union were born four children: Channing M., Albert B., J. Cheney (respectively, the president, the treasurer, and the vice-president and the secretary of the American Optical Co.), also a daughter, Mary Elizabeth. Wells died of cirrhosis of the liver, on Sept. 30, 1912.—(T. H. S.)

Wells, J. Soelberg. A celebrated English ophthalmologist, author of a text-book which was long a favorite in both England and America. Born in Norwich in 1824, he received his medical degree at Edinburgh in 1856 at the very late age of 32. Turning his attention at once to ophthalmology, he proceeded to Berlin, where he was long a student under A. von Graefe, and for a time the Master's first assistant. Returning to England in 1860, he assisted Sir William Bowman for about seven years at Moorfields. Later he was surgeon at Moorfields, as well as surgeon and professor of ophthalmology at King's College. He was a large, strong man, but in 1875, when but 51 years of age, began to be afflicted with some disease of the liver. He travelled for a time in search of health, but died at Cannes, Dec. 2, 1879.

Wells's more important ophthalmic writings are as follows: 1. On the Effects of the Solution of the Calabar Bean on the Accommodation of the Eye and on the Pupil. (*Med. Times and Gaz.*, 1863.) 2. Lectures on Diseases of the Eye Delivered at the Middlesex Hospital. Strabismus. (*Ibid.*) 3. Lectures on Cataract and the Modern Operations for its Treatment. (*Med. Times and Gaz.*, 1867.) 4. *A Treatise on the Diseases of the Eye.* (London, 1869; 2d ed., 1870; 3d ed., Phila., 1873.) 5. Strabismus. (*Lancet*, 1869.) 6. Ophthalmia Neonatorum. (*Med. Times and Gaz.*, 1869.) 7. Iritis. (*Ibid.*) 8. Abscess of the Frontal Sinus, Operation, Cure. (*Ib.*, 1870.) 9. An Abstract of a Course of Lectures on the Internal Diseases of the Eye as Seen with the Ophthalmoscope. (*Ib.*, 1871.) 10. Spasm of the Ciliary Muscle Treated by Duboisin. (*Ib.*, 1879.)—(T. H. S.)

Wells, William Charles. An important and early American ophthalmologist, who, however, passed nearly all his life abroad. His parents came to America from Scotland in 1753. Four years later, in Charleston, S. C., the subject of this sketch was born. In 1764, when only 11 years old, he was sent by his parents to Dumfries, Scotland, because of the better schooling to be had in that town. In 1770 he was admitted to the University of Edinburgh, but, in 1771, he returned to Charleston. Having studied medicine at Charleston for four years with Dr. Alexander Garden, a prominent physician and author, he returned to Edinburgh, and in 1780 received the degree of Doctor of Medicine from the University. In 1781 he again returned to Charleston and engaged in business as a printer and bookseller. After four more years in South Carolina, he betook himself to London, where, in 1788, he became a Licentiate of the Royal College of Physicians. In 1790 he was physician to the Finsburg Dispensary. In 1798 he was appointed assistant physician to St. Thomas's Hospital; and physician in 1800. In 1793 he was made a Fellow of the Royal Society and, in 1814, of the Royal Society of Edinburgh.

His most important works are: *"An Essay on Single Vision with Two Eyes, together with Experiments and Observations on Several Other Subjects in Optics"* (London, 1792); *"The Color of the Blood"* (1797); *"Vision"* (1811); *"An Essay on Dew, with Several Appearances Connected with it"* (London, 1814). Because of this last-named work he received the Rumford gold and silver medals.

Wells was a quiet, very unobtrusive man, and is said never to have succeeded in acquiring an extensive practice; yet his services to medicine in general and to ophthalmology in particular are very great indeed. Thus, he was perhaps the very first to show that the optic axis is not the visual line, and he clarified greatly current views about fusion, accommodation, convergence and orientation. He possesses for Americans an especial ophthalmo-historical importance because of his very early date. It is customary to say that Henry Willard Williams, of Boston (1821-1895) was the earliest person in America to make an exclusive specialty of ophthalmology, while Elkanah Williams, of Cincinnati (1822-1888) was the first to fill a chair set up exclusively for a teacher of ophthalmology. And these statements are, no doubt, correct, yet here was a man in South Carolina, who practised largely as a specialist, though not perhaps exclusively as such, well back in the 18th century.

Wells died Sept. 18, 1817. Four years later (the year in which Henry Willard Williams, of Boston, was born) there appeared a collective edition of the works of Wells, at the head of which appeared his autobiography.—(T. H. S.)

Welsbach light. See **Illumination,** especially p. 6144, Vol. VIII of this *Encyclopedia.*

Welz, Robert von. A distinguished German ophthalmologist, who turned his attention to ophthalmology after a long and successful career in other specialties. Born at Kelheim on the Danube, Dec. 15, 1814, he studied at first philosophy, then medicine. His medical degree was received in 1838. From 1840 till 1847 he was assistant physician at the Julius Hospital. In 1849, having received a travelling stipendium, he proceeded to Paris, where he made a special study of syphilis for a long time, and where he managed to produce the disease in apes and then to transfer it back to man. After having thus acquired a reputation as a syphilographer, he made the acquaintance of A. v. Graefe, under whose powerful influence he transferred his affections from syphilography to ophthalmology. He founded in Würzburg an eye infirmary, and in 1866 was made full professor of ophthalmology in the University—a position which he filled with rare ability. Many are the stories of his operative skill and didactic powers. He was also the inventor of a number of useful instruments. He died Nov. 12, 1878.—(T. H. S.)

Wengler, Dr. Author of "Ophthalmologisches Tagebuch aus den drei Ersten Jahren seiner Praxis" (*J. d. Chir. u. Augenheil.,* Vol. 38, pp. 542-628, 1848; also pp. 1-104, 1850). He was also for a time assistant to von Ammon in Dresden.—(T. H. S.)

Wenham prism. A quadrilateral prism used in the construction of binocular microscopes.

Wenzel, Jakob von. A celebrated Parisian ophthalmologist, son of Michael Johann Baptist, Baron von Wenzel. He received his degree at Paris, Mar. 23, 1779, and settled in the same city. He was world renowned as an operator, and published the following books: 1. *Dissert. Med. . . . 23 Mart.* 1779, *M. Claudio Lafisse, Doctore Medico præside, De Extractione Cataractae.* 2. *Traité de la Cataracte, avec des Observations qui Prouvent la Nécessité d'Inciser la Cornée Transparente et la Capsule Cristallin d'Une Manière Diverse selon les Différentes Especes de la Cataracte.* (Paris, 1786; 2d ed., 1806; Ger. Trans. Nuremberg, 1788; Eng. Trans. London, 1793.) 3. *Manuel de l'Oculiste, Ou Dictionnaire Ophthalmologique.* (2 vols.; Paris, 1808.) —(T. H. S.)

Wenzel, Michael Johann Baptist von. A celebrated Parisian ophthalmologist, who was the first to extract the lens in high-grade myopia (see **Ophthalmology, History of**). Born in Germany, he practised first in Paris, then in London, where he became court-oculist.

He died in 1790. He wrote no books or articles but many of his operations are described in the works of his son, Jakob von Wenzel (q. v.)—(T. H. S.)

Werde, Nicaise de. A famous blind Roman Catholic priest. The date of his birth has not been ascertained. We do, however, know that he was a native of Belgium and that he lived in the 15th century. At the age of 3 he became totally blind. Nevertheless, he attained to so high a degree of scholarship that he was appointed to the chair of common and civil law in the University of Cologne. Later, he received the degree of Doctor of Divinity from the University of Louvain. Because of his great ability and unquestioned zeal the Pope granted a special dispensation in his favor, suspending the law of the Church which provides that no one laboring under the infirmity of blindness can be admitted to holy orders.

De Werde continued in orders with great success until his death, which occurred at Cologne in 1492.

Werneck, Wilhelm. A distinguished Austrian ophthalmologist, who contributed greatly to our knowledge of the embryology and histology of the eye, and who first employed the solid copper sulphate stick, or crystal, in the treatment of ocular diseases. Hirschberg declares that he was also the first to examine microscopically the secretions of the conjunctiva. The date and place of his birth are unknown. He practised in various cities; in 1808, he was in Vicenza, a little later in Naples, and, in 1821, at Salernum. For an uncertain period at "Branau im Inn-Viertel" he had a private eye-infirmary. Still later he removed to Salzburg, where he died in 1843.

Werneck's ophthalmic writings are: 1. Aphoristische Betrachtung einiger Ophthalmologischer Gegenstände. (*Salzburger Medicin-Chirurg. Zeitung,* 1823, I, 113-135). 2. Ueber die Gaum-ennath und das Contagiöse Augenubel: Ein Sendschreiben des k.k. Oesterr. Regimentsarztes Dr. Werneck von C. F. Graefe. (*Aus Klagenfurth,* d. 18, Aug., 1823.) 3. Zur Aetiologie und Genesis des Grauen Staars, aus S. Natur-historisch.-Medic. Skizzen von Salzburg, und dessen Nächster Umgebung (*Clarus u. Radius Wöchentl. Beitr. z. Med.-Chir. Klinik,* II, N. 23 and 24, Aug., 1833.) 4. Mikroskopisch-Anatomische Betrachtungen über die Wasserhaut und das Linsen-System des Auges. (Ammon's *Zeitschr. f. Ophthalm.* IV, pp. 1-17, 1835.) 5. Einige Resultate meiner an Verschiedenen Thieren Gemachten Experimente über die Traumatische Reaction bei Verwundungen der Kapsel und der Linse, nebst Angabe jener Erfahrungen über diese Reaction beim Menschen. (*Ib.,* pp. 19-27.) 6. Beiträge zur Gewebelehre des

Krystallkörpers. (*Ib.*, V, pp. 403-428, 1837.) 7. Lettres au Doct. F. Cunier, sur la Structure de la Conjonctive. (*Annal. d'oc.*, XIV, 1839.)—(T. H. S.)

Wernher, Adolph. A celebrated surgeon of Giessen, Germany, of some importance in ophthalmology. Born Mar. 20, 1809, at Mainz, he studied at Giessen, Heidelberg, Berlin and Halle, returning to Giessen for his medical degree in 1832. For a time he practised at Offenbach on the Main, but in 1835 returned to Giessen to accept the extraordinary professorship of surgery in the University. He was also for a time assistant physician to the Surgical Hospital at Giessen. In 1837 he was promoted to the ordinary chair of surgery, and in 1845 the additional professorship of pathological anatomy. About this time he wrote his masterpiece, "*Handb. der Allgemeinen und Speciellen Chirurgie*" (4 vols., Giessen, 1846-57). This work is especially full and clear on the surgery of the eye. In fact, Wernher was a very active ophthalmologist, as well as anatomist and general surgeon. In 1859 he infected his eyes with virus of trachoma, and, from that time onward, did but few and simple operations. He continued, however, to lecture and to write. The preservation of a modicum of sight he owed to Alfred von Graefe—who repeatedly punctured for him the thin floor of a persistent corneal ulcer—then a comparatively new proceeding. In 1878 Wernher retired from all didactic, as well as medical and surgical activity, and removed to Mayence, where he died July 14, 1883.—(T. H. S.)

Wernicke's pseudo-ophthalmoplegia. See this sub-head under **Neurology of the eye.**

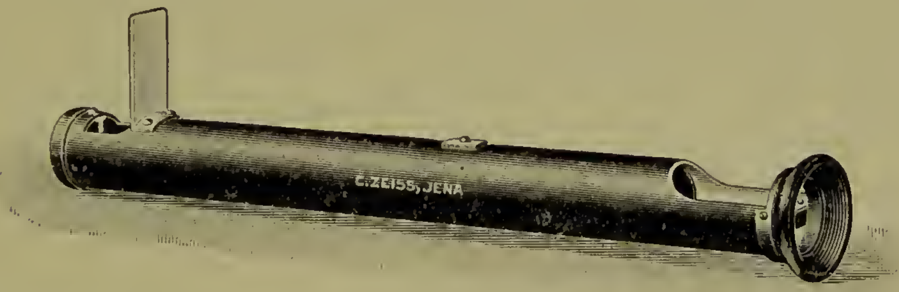
Wernicke's reaction. WERNICKE SYMPTOM OR SIGN. See **Hemiopia,** p. 5768, Vol. VIII; and p. 4621, Vol. VI of this *Encyclopedia.*

Wessely's keratometer. This instrument is not, as might be judged from the name, an ophthalmometer but a device for measuring the diameter of the cornea; also for determining the distance between the apex of the cornea and the pole (vertex) of the inner surface of an ophthalmic lens. The instrument was designed by Wessely, and consists of a tube with a plano-convex lens at one end and a millimeter scale, for direct measurement, at the other end.—(C. F. P.)

Since the curved profile of the cornea renders it impossible to apply a straight-edged scale the plan has been adopted of eliminating errors by measuring the image of an object as seen by parallel rays with the eye applied at the principal focus of a lens, i.e., by what is known as a telecentric arrangement.

When the observation is made through a stop situated in the posterior focal plane F' of a lens it follows that the rays proceeding from the object to the lens will be parallel to its axis (see the figure). If now a scale be placed in front of the object so a correct reading of the size of the object will be obtained, no matter what its position may be.

The keratometer is constructed upon this principle. The stop is situated in the posterior focal plane of a + 6-diopter lens mounted within the tube. The opposite end of the tube carries a vulcanite ring, by means of which the instrument may be rested upon the margin of the orbital cavity of the patient's eye. Within the ring a scale divided into half millimetres is so mounted that its upper edge may pass accurately through the centre of the ring. In front of the ring the tube has a large excision through which sufficient light may reach the scale and the patient's eye.



Keratometer of Wessely.

The scale is situated near the anterior focus of the lens, and the same applies to the cornea which is to be measured, and hence both the scale and the cornea can easily be seen magnified 1.5 times by an eye placed in front of the stop. The tube has another excision in front of the stop. Within this excision the tube carries a small white mark, upon which the patient is required to fix his sight. A white screen serves to illuminate the fixing mark with diffuse reflected light.

A cornea of any diameter may be measured with the instrument. All that is necessary is to rotate the instrument whilst the hard rubber ring is placed upon the fingers which are being used for stretching the eyelids apart. The instrument is also available for measuring the pupils; it may, in fact, be used for measuring the diameter of bodies of any shape whose greatest diameter does not exceed 20 mm.

The keratometer also affords a particularly simple and reliable means of measuring the distance between the apices of the cornea and the spectacle lenses. To carry out this measurement it is best to unscrew the vulcanite ring. The observer should then so place himself that the centre line of the instrument is at right angles to the patient's line of sight when he is looking straight ahead.

The Bausch and Lomb Co. have also marketed the same instrument.

West operation. WINDOW RESECTION. In addition to the matter on p. 1917, Vol. III of this *Encyclopedia,* it may be said here that W. B. Chamberlin (*Trans. Sec. Oph. A. M. A.,* p. 177, 1917) modifies the West operation, as described by himself. A probe is inserted into the canaliculus, sac and duct. This probe is held in place by an assistant. When the duct is freely uncovered the point of the probe is directed inward towards the septum, thus bulging in its septal wall. A thin scalpel is now inserted between the probe and the lateral nasal wall, and the incision carried well up beyond the isthmus, so that the probe ultimately passes horizontally into the nose.

Mosher reported four cases that he had operated on. Three of them were of two years' duration. One case was of mucocele of the sac. After nine months there was no return or swelling of the sac and the opening into the nose was patent. The second was one of long standing, a suppurative sac, with a skin fistula. The eye was all right and the tears ran over only when the patient got cold. A third patient had a suppurative sac for seventeen years complicated with an infected mucocele of the ethmoid labyrinth. There was a patent opening into the nose and the tears ran over only on a cold day, or in a strong wind. The fourth patient had a bony occlusion of the nasal duct. This man was wearing a style at the end of ten months, and with it there was no running over of tears except in a strong wind.

Westphal-Piltz reaction. GIFFORD REFLEX. WESTPHAL'S SIGN. See p. 5384, Vol. VII of this *Encyclopedia.*

Wet cupping. See **Blood-letting, Local,** p. 1226, Vol. II; **Artificial leech,** p. 633, Vol. I and p. 3584, Vol. V of this *Encyclopedia.*

Weyant, Harry W. A well-known Philadelphia ophthalmologist. Born in Philadelphia, Oct. 23, 1869, son of Harry Read and Alice (Van Mete) Weyant, he received the medical degree at the university of Pennsylvania in 1895. Settling in Philadelphia as ophthalmologist and oto-laryngologist, he became assistant ophthalmic surgeon at the Protestant Episcopal Hospital, and was for 21 years police surgeon of the Tenth District.

Weyant was a small, lean man, smooth-faced and of dark complexion, very vivacious and gay in manner. He married on April 12, 1899, Miss Nellie M. Hoover. There were no children. He died at his home, Nov. 2, 1916, from pneumonia.—(T. H. S.)

Weyert, Ferdinand. An eminent ophthalmologist of St. Petersburg, Russia. Born in 1837, he received the degree of M.D. from the University of Dorpat and studied ophthalmology in Vienna, Paris, and Berlin. Returning to St. Petersburg, he soon acquired a great reputation as an operator, and, about 1867, was appointed senior physician and chief of the directorate of the St. Petersburg Eye Institute—a post which he held until his death. He died at his home in St. Petersburg, Feb. 3, 1903.—(T. H. S.)

Wheat. *Triticum vulgare.* A wheat-bread poultice, in ancient Greco-Roman times, was highly esteemed as a remedy for any sort or kind of inflammation. It was, therefore, often employed in painful affections of the eyes. A poultice of wheat-flour mingled with the white of egg was also placed upon the forehead to check too copious ocular discharges.—(T. H. S.)

Wheatley, Arthur William. A well-known English surgeon, who paid considerable attention to ophthalmology, and who for some years was consulting surgeon to the Western Ophthalmic Hospital, Marylebone Road, London. He wrote a number of articles, dealing with conjunctival epithelioma, cataract extraction and neuro-retinitis. He died in 1910.—(T. H. S.)

Wheatstone, Charles. One of the most important of English natural philosophers, the founder of modern telegraphy, deviser of the acoucryptophone, and (a matter of some significance to ophthalmologists) inventor (1838) of the reflecting stereoscope (q. v. in this *Encyclopedia*). He was born at Gloucester in February, 1802, removed with his father to London in 1806, became, in 1834, professor of experimental philosophy at King's College, London, a Fellow of the Royal Society in 1837, and, after the invention of the automatic telegraph, was knighted. He died in Paris, Oct. 19, 1875, as the result of a scientific experiment.—(T. H. S.)

Wheel, Green's astigmic. See under **Chart, Astigmatic,** p. 2008, Vol. III of this *Encyclopedia.*

Whewell, William. A British philosopher and historian of science, author of the term, "astigmatism." (See Hewson, "*Mackenzie on the Eye,*" Phila., 1855, p. 868.) Born at Lancaster, Eng., May 24, 1794, the son of a carpenter, he studied at Trinity College, Cambridge, was professor of mineralogy from 1828 to 1832 and of moral theology and casuistical divinity from 1838 to 1855. He died Mar. 6, 1866. His most important writing is "*History of the Inductive Sciences from the Earliest to the Present Time.*"—(T. H. S.)

Whisker incision. A term employed by Maddox (*Ophthalmic Record,* p. 342, July, 1916) to describe a form of bridge flap in cataract extraction. In this, both the puncture and the counter-puncture are made through a little conjunctiva on each side of the cornea, though the knife is made to emerge through the limbus at the apex perpendicularly to the surface of the cornea. This allows a thread loop to be inserted easily, though the extremities of the incision are covered with conjunctiva of so short a breadth as rarely to unfold.

White-cloud illuminator. A surface of plaster of Paris or ground glass for reflecting light upon microscopic objects and thus obtaining the effect of illumination from a white cloud.

Whitehead's varnish. A solution of one part of iodoform and six parts of compound tincture of benzoin in ether, used in ophthalmic surgery to facilitate the healing of the swollen and displaced flaps of a penetrating wound of the cornea.

White light. In *physics*, the light which comes directly from the sun, and which has not been decomposed by refraction, either atmospherically or artificially by a prism.

White, Lunar. See **Eyes of soldiers, sailors, etc., Examination of the,** in this *Encyclopedia.*

White nigger. KAKERLAKE. A term originally applied by the Portuguese to white negroes met with on the west coast of Africa. A person in whom the normal pigmentation of the epidermis, the hair, the iris, and the choroid is congenitally deficient, the skin being uncommonly white, the hair yellowish, resembling flax or silk in color; and the eyes pinkish and usually affected with photophobia, more or less blepharospasm, and occasionally nystagmus. The term is also applied to the lower animals having like peculiarities.

White, Normal. This standard of whitness was adopted by Koenig, and is made by burning a thread of aluminum and allowing the vapor to deposit on a sheet of paper. This deposit reflects about two-thirds of the light, and its whiteness is about that of snow.

White precipitate of mercury. See **Mercury, White precipitate of,** p. 7655, Vol. X of this *Encyclopedia.*

White's ointment. See **Bichlorid-vaselin,** p. 949, Vol. II of this *Encyclopedia.* The problem of obtaining the complete antiseptic action of sublimate upon the ocular tissues without disturbing unduly the vascular supply of the parts and without inducing discomfort, is solved by the use of a formula proposed by J. A. White. He found that while it is impossible to use, especially in operative work, such decided germicide solutions as 1:3,000 in water, that strength might be employed as an ointment with vaselin. His formula is: ℞—Hydrarg. bichlor., gr. 1/6; sodii chlor., gr. 5/6; alcohol dil., q. s.; petrolati, ℥j.

Dissolve the sublimate and the common salt in a few drops of dilute alcohol and mix with the vaselin, which has been previously kept at a temperature of 212° F. for half an hour. Stir until cool. This may be put into soft capsules for individual use, or kept as an antiseptic base for atropin and other ointments. The Editor has prescribed this salve and used it extensively in private, dispensary and hospital work and can recommend it as a most useful application to the sac when a reliable antiseptic is desired. It is his practice to fill the sac with the ointment twice in 24 hours as one of the preliminaries to major operations on the globe; also to prescribe it extensively alone and in conjunction with other remedies for the home treatment of several forms of blepharitis.

J. A. Lippincott, advises a modification of the ointment, especially in infected ulcers of the cornea, by the addition of lanolin, which takes up the watery solution of the bichloride better than vaselin alone. His formula is: ℞—Hydrarg. bichlor., gr. i; sodi chlor., gr. vi; petrolati, ℥ii; lanolin., ℥iii.

White vaselin. See **Cosmolin,** p. 3543, Vol. V of this *Encyclopedia.*

White vitriol. See **Zinc sulphate** herein.

White wax. See **Wax.**

Whittell, Alexander Pope. An American ophthalmologist, of much ability as an operator. Born at Mt. Vernon, N. Y., in 1850, he received his liberal education in France. His professional training was at the University of California, from which institution he received the degree of M.D. in 1865. For a time he practised with the late Dr. William F. Smith, of San Francisco, who advanced him funds for a three years' course of study in Germany and France.

Returning to America, he became assistant to Ferrer, in San Francisco. He was President of the San Francisco County Medical Society in 1891, and was for many years chief of the Eye and Ear Department in the San Francisco Polyclinic.

He was never a popular or magnetic man, but was one of singular purity and rectitude. He was noted especially for his friendliness to the younger members of his profession.

Whittell died suddenly at Lake Tahoe, July, 1893. He left a wife and one daughter, the latter now married to a German nobleman.—(T. H. S.)

Whooping-cough. Pertussis. This infectious disease is characterized by catarrh of the respiratory tract and peculiar paroxysms of cough, ending in a prolonged crowing or whooping respiration. The disease is most frequently met in children, is much more prevalent in cold weather, and is very contagious, the virus being apparently associated with the sputum. The disease is apt to be complicated with catarrhal pneumonia, pulmonary collapse, emphysema, convulsions, and hemorrhages into the eye, ear, or brain, and severe cases are sometimes followed by chronic bronchitis, tuberculosis, or nephritis.

Parsons (*Pathology of the Eye,* p. 1253) catalogues a large number of ocular complications of this disease. The most common are conjunctival hemorrhages and conjunctivitis (Weeks); much rarer are orbital hemorrhages with exophthalmos. Cases are reported of hyphema, retinal hemorrhage, intra-ocular hemorrhage and detachment of the retina, subluxation of the lens and optic neuritis. Partial or complete blindness may follow cerebral hemorrhage or involvement of the optic nerve in the orbit. Homonymous hemianopia, amblyopia during the paroxysms, iridocyclitis, optic neuritis with subsequent atrophy, paralysis of the sixth and seventh nerves, etc., have also been recorded.

Among these numerous observations is one of optic neuritis, by E. Weigmann (*Klin. Monatsbl. f. Augenheilk.*, April, 1912) who was consulted May 3rd, 1911, by a woman who had been the subject of pertussis, aged 40, on account of occasional obstructions of sight which set in after changing the position of the body or head, *e.g.*, after stooping in reading and writing. Vision was nearly normal, but the visual field showed a slight contraction for colors. Both optic disks were very red, their borders indistinct, the veins enlarged, the tissue of the disks slightly opaque, the lamina cribrosa and walls of the vessels on the disks veiled. The disks were swollen, but not projecting. Near the left disk were two small retinal hemorrhages. The treatment consisted in ironsajodin. On January 25, 1912, the ophthalmoscopic condition was about the same, but the disks were somewhat paler and the arteries narrower. There was a slight contraction of the left visual field in the inferior nasal quadrant.

The writer attributes the obscurations after changing the position of the head to transient disturbances of circulation. The affection of the optic nerve may have been produced mechanically by intracranial transudations in consequence of venous stasis brought about by the paroxysms of whooping cough, or by hemorrhages into the optic sheaths, or by toxins of whooping-cough bacilli, described by Bordet and Gengou.

E. S. Clouting (*N. Y. Med. Journ.*, p. 1051, May 22, 1915) also records a case of optic neuritis following whooping cough in a boy, aged nine. It was suggested that in this case the optic disease followed an encephalitis the result of the pertussis.

Wicherkiewicz, Victor Boleslaus. A celebrated ophthalmologist of Cracow, Poland. Born July 7, 1847, at Keynia, Posen, he received his medical degree in 1872, presenting as dissertation, *"Ueber Sarcome u. ihr Vorkommen im Mediastinum."* In 1874 he settled at Breslau, became assistant to Prof. Foerster, and, shortly after, physician to the Silesian ophthalmic institute. In 1875, however, he went to Wiesbaden where he studied for two years more with A. Pagenstecher. In 1877 he spent some time in Paris and London.

Returning to Posen, he settled as ophthalmologist, and founded both a private ophthalmic hospital and a public charity hospital for eye patients.

Wickerkiewicz was an expert operator, and an excellent, as well as prolific, writer on almost every branch of ophthalmology. Most of his articles appeared in the *Cracow Przeglad Lekarsi* and in the *Klinische Monatsblätter für Augenheilkunde.* According to Edward Jackson, "But few European writers have contributed so much to the literature of ophthalmology in the last score of years, or so much that was original; and upon such a wide range of subjects."

Wicherkiewicz died Dec. 7, 1915, in an Austrian military reserve hospital.—(T. H. S.)

Wide-aperture lenses. See p. 7340, Vol. X, of this *Encyclopedia.*

Widmark, Erik Johann. The first professor of ophthalmology in Sweden, and a prominent investigator into the causes of snow-blindness, ophthalmia electrica, and erythema solare. Born in 1850, he began, in 1888, together with J. Bjerrum, of Copenhagen, to edit the *"Nordisk Optalmologisk Tidskrift,"* and did not sever his connection with that journal till shortly before his death. In 1891 he was appointed professor of ophthalmology at the Karolinska Medico-Kirurgiska Institutet. He died of cancer of the intestines at Stockholm, Dec. 15, 1909.—(T. H. S.)

Widmark's conjunctivitis. As de Schweinitz (*Text-Book*, p. 306) has pointed out, Widmark and T. Harrison Butler have described a form of conjunctival disease characterized by congestion of the inferior tarsal conjunctiva and of this membrane in the lower epibulbar expansion. Part or all of the affected area stains with fluorescein. Slight stippling of the cornea may be present. Brow pain and occipital headache may precede the inflammation. Massage with a 1 per cent. ointment of yellow oxid of mercury, according to Butler, is the best treatment.

Wigwag. See **Eyes of soldiers, sailors, etc., Examination of the.**

Wilbrand's bed-perimeter. See **Bed-perimeter, Wilbrand's,** p. 921, Vol. I of this *Encyclopedia.*

Wilde, William Robert Wills. A famous Irish scholar and physician, widely known as a specialist in diseases of the ear, and also, to some extent, as an ophthalmologist. Born in 1815 at Castlereagh, Ireland, the son of a country doctor, he studied at first in Dublin, but later, when his attention had been directed to ophthalmology and otology, at London, Paris, Vienna and Berlin.

He settled in Dublin in 1841, as general practitioner, but, from the very beginning, devoted himself especially to diseases of the eye and ear. He it was who devised "Wilde's incision," now almost abandoned but of universal application for three-fourths of a century. He founded, in 1844, the Dublin Ophthalmic Dispensary, lectured for many years on ophthalmology and otology at the Park Street Medical School, and from 1846 until his death was editor of the *Dublin Journal of the Medical Sciences.* In 1853 he was appointed surgeon oculist to the Queen in Ireland, and in 1861 was knighted because of his services as assistant commissioner of the Census of Ireland. In 1863 he was given the degree of M.D., *honoris causa,* by Dublin University, and ten years later the golden Cunningham medal by the Royal Irish Academy. He died April 19, 1876. The celebrated author, Oscar Wilde, was his son.

In addition to his more important books and articles (which were all on diseases of the ear) Sir William Wilde wrote as follows: 1. On the Employment of Belladonna and Atropin in Ophthalmology. (*Ann. d'Oc.* XVII, 1847, pp. 21-24.) 2. *Observations on the Epidemic Ophthalmia which has Prevailed in the Workhouses and Schools of the Tipperary and Athlone Unions.* (Dublin, 1841, p. 28.) 3. Inflammation of the Ciliary Body. (*Ann. d'Oc.* XXXII, 1854, pp. 223-230.) 4. Accidental Discovery of a One-Sided Visual Disturbance. (*Med. Times and Gazette,* Jan. 14, 1854.) 5. *Malformation of the Organs of Sight.* (London, 1862.)—(T. H. S.)

Wilder, A. M. A well-known American ophthalmologist. Born in Boston, Mass., May 3, 1840, he entered the Medical Department of Harvard University in 1861. One year later, he joined the U. S. Army, and, in 1863, while stationed in Washington, he entered Georgetown University, from which institution he received his medical degree. At the close of the War he studied ophthalmology with Henry Willard Williams, of Boston. Afterward, in company with John Green (who later settled in St. Louis) he studied his specialty in London and Paris.

Returning to America in 1866, he settled in Lawrence, Kas., where he practised general medicine and surgery, as well as ophthalmology and otology, until 1875, when he removed to San Francisco, Calif., forming there a partnership with George H. Powers in the practice of ophthalmology and oto-laryngology exclusively. In 1882 he was made professor of ophthalmology and otology in the Medical Department of the University of California. For several years he was surgeon to the First Regiment, N. G. C., and he was also for a long time a member of the Harvard Club of San Francisco. He died in 1885.—(T. H. S.)

Wild hairs. Irregularly placed eyelashes in entropion and trichiasis (q. v.). See, also, **Acid, Nitric,** p. 71, Vol. I of this *Encyclopedia.*

Wild tansy. See **Pollantin,** p. 10307, Vol. XIII of this *Encyclopedia.*

Willburg, von. An ophthalmologist of the latter third of the 18th century, celebrated for having proposed (as a modernized method) a modification of "depression," or "couching," which he called "reclination," for the relief of cataract. Mere "depression," or "couching" (q. v.), is possibly older than civilization itself. It was known throughout antiquity (scleronyxis only) and, alone or combined with discission, was the solitary method employed. "Reclination," von Willburg's modification of "depression," consists of a dislocation of the lens not merely downward, but downward and backward, so that the anterior surface of the crystalline looks upwards, its posterior surface, however, downward, being, in fact, in contact with the floor of the vitreous chamber.

Daviel, in 1748, published his first account of the extraction method, which had been invented by him, but this procedure, spite of its great advantages over a mere dislocation of the lens, in whatsoever manner the dislocation might be performed, did not reach universal acceptance till nearly the middle of the 19th century.

Keratonyxis, as a preliminary step in the performance of either depression or reclination, was not invented until 1806, when it was first described by Buchhorn, in his graduation thesis, entitled *"De Keratonyxide."*—(T. H. S.)

Willebrand, Knut Felix von. A well-known Helsingfors surgeon, who devoted considerable attention to the eye. Born June 11, 1814, at Uskela, Finland, he became in 1840 Doctor of Medicine and Surgery at Helsingfors. He wrote a number of minor ophthalmologic articles for A. v. Graefe's *Archiv,* I and II, and died Jan. 18, 1893.—(T. H. S.)

Williams, Charles Herbert. A famous American ophthalmologist. Born at Boston, April 19, 1850, he was a son of the still more famous Henry Willard Williams, the first in America to deliver a course of lectures on the eye, and of Elizabeth Dewey Williams. His B.A. was received at Harvard University in 1871, his medical degree in 1874. After a number of years devoted to the study of ophthalmology in European centers, he returned to Boston, where he practised for a time with his father. He married, on Oct. 1, 1884, Caroline Ellis Fisher; afterward removing to Chicago as ophthalmic surgeon to the Chicago and Northwestern Railway. In 1895, he returned to Boston, where he practised with his brother, Dr. E. R. Williams.

Charles H. Williams was one of the earliest investigators of color-blindness in this country and an excellent writer on that subject, as well as on errors of refraction. He will, however, be especially remembered as the first to extract a foreign body from the eye by the aid of a Roentgen picture. The picture, we may add, was, in the case in question, made by yet another brother, Dr. F. H. Williams.

Charles H. Williams was ophthalmologist to the Massachusetts Eye and Ear Infirmary and to the Boston City Hospital, a member of the Chicago and of the American Ophthalmological Societies.

Charles Williams was, like his father, a large, tall man, of fair complexion, gray of eye and hair, mustached, quiet and reserved in manner. He was markedly fond of animals—dogs, cats, and horses in particular. He was a Republican in politics, a member of the Boston Common Council, a trustee of the Township High School, and in many other ways active in civic affairs. He died at his home in Cambridge, Mass., June 9, 1918, survived by his widow and two children.

The following passage is from the *"Boston Evening Transcript"*: "By the death of Dr. Charles H. Williams his friends have lost a loyal, true and devoted companion, one whom it was a joy to meet, who was always ready to see the best in people, free from envy or any small or narrow point of view. His place in their hearts can never be filled. The community has lost a faithful, unselfish citizen, never seeking his own gain, but glad to contribute his skill and aid in any direction needed, giving the world the benefit of his many inventions, never thinking of profit or fame. Truly of such a man we may quote the lines,

'This man is freed from servile bands
Of hope to rise or fear to fall,
Lord of himself, though not of lands,
And having nothing, yet hath all.' "—(T. H. S.)

Williams, Cornelius. A well-known ophthalmologist of St. Paul, Minn. Born in Kentucky in 1848, he removed in 1864 to Minnesota but later returned to Kentucky. His medical degree was received at the College of Physicians and Surgeons in the City of New York in 1874. Having studied ophthalmology and oto-laryngology and practised both these specialties in New York City for a number of years, he removed in 1882 to St. Paul. In 1901 he was president of the Ramsey County Medical Society. At some time in his career he was admitted to the Minnesota bar, and, on a number of occasions, conducted his own law-suits—each time, it is said, successfully.

Dr. Williams, in his later years, was a very shy man, his diffidence being said to have arisen in this way. Having iritis and a corneal ulcer, he was operated on in New York City, undergoing iridectomy simply as a last resort. The operation was unsuccessful, the iris becoming incarcerated and a complete leucoma and staphyloma putting in an appearance a little later. Dr. Williams, who had always been extremely sensitive about his personal appearance, was very much more so after these unfortunate results. One of the Doctor's hobbies was letter-writing, and among his correspondents he numbered some of the ablest ophthalmologists in this country and Europe.

Dr. Williams died at St. Luke's Hospital, St. Paul, Dec. 30, 1918, aged 70 years. His widow had predeceased him, but he was survived by one son.—(T. H. S.)

Williams, Elkanah. A famous American ophthalmologist, the first regularly accredited physician in America to confine his practice to ophthalmology and oto-laryngology. Born in Lawrence County, Indiana, Dec. 19, 1822, the son of Isaac Williams, a captain in the U. S. Army in the War of 1812, he received the degree of A.B. from Asbury University (now De Pauw) at Greencastle, Ind., and the degree of M.D. in 1850 at the University of Louisville. After about two years of successful general practice, he returned to Louisville and took another course of lectures. In the spring of 1852 he settled in Cincinnati, but, in the following November, proceeded to Europe for the study of ophthalmology. For eighteen months he studied with Desmarres, Nélaton and Roux in Paris, and then for a number of months at Moorfields, in London. Here he received instruction from Bowman, Dixon, Wordsworth, Critchett and others, and is said to have been for a time almost the only student in the great Moorfields Hospital. He then, for a very few months, pursued his studies at Prague, Vienna, and Berlin.

In 1855 he returned to Cincinnati, where he practised as ophthalmologist and oto-laryngologist exclusively, and then became "the first regularly accredited physician in America who confined his practice strictly to these branches." In 1860 a chair of ophthalmology was established at Miami Medical College, and the subject of this sketch was made the first incumbent of the new position. The statement has often been made that this fact constituted Dr. Elkanah Williams the first to deliver a course of lectures on ophthalmology in this country.

But such a statement is surely incorrect. Elkanah Williams was indeed the first in America to deliver a course of *didactic* lectures on ophthalmology, but the first to lecture (clinically it was) on our specialty was Henry Willard Williams, of Boston, who, in 1850, gave a clinical course in ophthalmology to a class of students at Harvard Medical School. (See **Williams, Henry Willard,** in this *Encyclopedia*).

When the Civil War broke out, Dr. Elkanah Williams served as assistant surgeon to the U. S. Marine Hospital at Cincinnati for a number of years.

Williams was a member of a number of International Medical Congresses, of the American Ophthalmological Society and of the International Otological Society. He was also a member of the staff of a number of hospitals.

He was twice married. His first wife bore him a daughter (the only child he ever had), who died in 1851. With his second wife he celebrated his silver wedding not long before his death.

Dr. Williams died Oct. 6, 1888.

Regarding the physical appearance and personal character of the first American ophthalmologist, we quote the following passages from Dr. R. Sattler: "Tall and broad-shouldered, with a merry facial expression which mirrored his genial character, eyes which by their soft and penetrating gaze fascinated the attention and invited discussion, associated with this a frank and earnest address, uniformly courteous manners, devoid of all studied or acquired polish, one could but be impressed that with him the art of being and appearing agreeable was a natural or spontaneous attribute or gift. Endowed with a disposition broad, generous, and affectionate, an even and jolly temperament, he attracted many people, and in his social as well as his professional relation he was always a conspicuous man, in particular because his ready conversational power, adaptive ability, and diverse funds of information rendered easy an approach with strangers.

"His fund for story telling was, among his friends, almost proverbial, and this, as well as his knack for their favorable introduction, must also be considered one of his characteristics; certain it is that it afforded him as much pleasure as it often did his listener.

"In his judgment of men and their actions, he was as charitable as he was liberal and just; firm in his own convictions pertaining to religious and secular affairs, he accorded the most respectful recognition to the views of others. He was an upright Christian, and his conduct in religious matters was exemplary. To his own cherished religious views, and to the simple creed of his church, he was zealously devoted."

A list of Dr. Williams's writings would be too long for insertion here. There exists, however, a privately collected book, in which his articles, or at least the most of them, were brought together by Mrs. Williams, with an artistic title-page and a table of contents (running to many pages) from the pen of his former pupil and assistant, the late Dr. (Major) Christian R. Holmes, of Cincinnati.—(T. H. S.)

Williams, Henry Willard. A celebrated American ophthalmologist, the first in this country to deliver a course of lectures on diseases of the eye as a specialty. Born in Boston, Dec. 11, 1821, son of Willard and Elizabeth Osgood Williams, he received his general education in the Latin schools at Boston and Salem. In his seventeenth year he entered a counting-room on Central Wharf in Boston, but very shortly afterward took up the position of Secretary and Publishing Agent in the office of the Massachusetts Anti-Slavery Society. Later still he began to study medicine, and, at the age of twenty-three, matriculated in the Harvard Medical School. At the end of his second course of lectures he went to Europe, where he studied medicine for three years more, and, at length, returning to Harvard, received the degree of Doctor in Medicine from that institution in 1849.

He was then for a time assistant physician at the Cholera Hospital on Fort Hill. In 1849-51 he was one of the visiting district physicians to the Boston Dispensary. In 1850 he became instructor in the theory and practice of medicine in the Boylston Medical School, a position which he held for five years. In 1850, furthermore, he delivered to a class of Harvard medical students a course of clinical lectures on diseases of the eye, apart, that is, from any other lectures, as, for example, on medicine in general or general surgery.

In course of time Williams relinquished absolutely all practice except that pertaining to the eye, being, perhaps, the first in America to do this, though Elkanah Williams, of Cincinnati, was the first to restrict his practice to the eye, ear, nose and throat. Henry Willard Williams, shortly after the restriction of his practice, became an ophthalmologist of international reputation. He was ophthalmic surgeon to the Boston Dispensary and to the City Hospital, and lecturer and professor of ophthalmology at Harvard University. He was a member of the American Ophthalmological Society (of which he was one of the founders in 1864, and for many years the president); a member of the International Medical Congress at Philadelphia in 1876; Foreign Honorary Fellow of the Edinburgh Medico-Chirurgical Society; member of the Heidelberger Ophthalmologische Gesellschaft, etc.

Dr. Williams, as the result of a severe attack of influenza, resigned, in the spring of 1891, both his teaching position and his hospital appointments. On so doing, he endowed at Harvard the chair he had just given up. From the effects of the influenza he never fully recovered. He died, without suffering, early in the morning of June 13, 1895.

Dr. Williams married, in 1848, Elizabeth Dewé, of London, England. Of the union were born two sons, Charles Herbert Williams, a well known ophthalmologist of Boston, and Francis Henry Williams, also of Boston, a general practitioner, who was recently professor of therapeutics at Harvard. Dr. F. H. Williams, we may add, was the first to attempt a demonstration of a foreign body in the eyeball by means of a radiograph, and his brother, Dr. Charles H. Williams, was the first to remove a foreign body so shown.

The first wife having died, Dr. Henry Willard Williams married, in 1860, Elizabeth Adeline Low, of Jamaica Plain, Mass. Of the union were born a daughter and four sons.

Dr. Williams was a large and powerful man, of very impressive presence. His speech was slow, distinct, well modulated and concise. The writer recalls with a kind of pang the very pleasant (yet also very melancholy) call which he made at the old Doctor's office, many years ago, with the object of securing relief for his own somewhat troublesome visual apparatus, only to learn, however, that the first of American ophthalmologists had become an invalid, and, therefore, could practise no longer. "You had better," said he, "see Dr. Wadsworth." He proceeded, however, weak as he was, to ask a large number of questions, then to compare views, finally expressing his sympathy in no unmistakable terms. He went to the door with me, and, having said "Good-bye, sir," added again and yet again his wish that he might have been able to be of service to me. "But all that," said he, waving his hand, as if putting something definitely to one side, "is over."

Concerning the personal character of Dr. Williams, I quote the following from Dr. John Green, Sr., of St. Louis: "In the wide range of activities represented by the many professional, scientific, and other organizations with which he was connected, Dr. Williams was conspicuous for fidelity and punctuality in the discharge of duty. It was his greatest happiness to be constantly employed, yet he never seemed to be hurried, and rarely appeared to be overworked. He found the relaxation which he needed in variety of occupation, in his family, and in the companionship of old and intimate friends. Some of his closest friendships were with physicians, companions in early struggles and in later successes, most of whom he survived. In the nature of things, their places, as one by one they became vacant, could never be adequately filled. Of younger men only the comparatively small number whom he admitted to a closer intimacy can fully appreciate the strong and fine qualities which endeared him to the friends who went before him. To quote the words of a friend, who knew him long and well: 'He impressed his strong personality on his medical brethren, as he lived and worked largely for them. He was, all in all, a doctor first, and other things afterwards. . . . Of large stature and strong character, he was a conspicuous figure on all medical occasions. He was . . . a forcible and persuasive speaker, and an excellent presiding officer. . . . Conservative to a fault, yet he was kindly and thoughtful of his professional brothers. . . . He did not grow old, but retained his enthusiasm to a remarkable degree. . . . He was as sturdy and honest in suppressing quackery as in favoring his weaker medical brothers with professional advice and with substantial aid. . . . His mind was virile, set, consistent, naturally meeting with and contending with opposition. . . . He left his mark on his times and on our community.' "

In a literary way Dr. Williams was also very active. Aside from his numerous journal articles, case reports, book reviews, etc., we may mention: 1. *Sichel's "Spectacles: Their Uses and Abuses in Long and Shortsightedness."* (Trans. by H. W. Williams, 1850.) 2. *Practical Guide to the Study of the Diseases of the Eye.* (1862.) 3. *Recent Advances in Ophthalmic Sciences.* (Boylston Prize Essay, 1865.) 4. *The Diagnosis and Treatment of Diseases of the Eye.* (1881; 2d ed., 1886.)—(T. H. S.)

Williams, John. An Anglo-French quack, who flourished like an ill weed in the early portion of the 18th century. In 1814 he began to practice at Paris, but in 1830 his license was revoked by the change in political affairs. He did not operate for cataract, but sold for 500 francs a remedy which would prepare the patient for the operation and make it safer.—(T. H. S.)

Willis, Thomas. A celebrated anatomist, for whom is called the remarkable vascular system at the base of the brain—the "circle of Willis." Born Feb. 6, 1622, at Great Bedurin, Wiltshire, England, he studied at first theology, later, however (and chiefly for political reasons), natural philosophy and medicine. He received the baccalaureate degree in medicine at Oxford in 1646. In 1660 he was called to the chair of natural philosophy in his *alma mater,* and, soon after, received his doctorate. In 1666 he settled in London, where he met with much success as a general practitioner, but where, nevertheless, his life would seem to have been embittered by the constant machinations of professional enemies. According to Pagel, his death—which occurred Nov. 11, 1675, in the 54th year of his age—resulted directly from these unscrupulous plottings.

Of his numerous writings, we need to mention here only his "*Cerebri anatome Nervorumque Descrittio et Usus,* Studio Thomae Willis, M.D., Natural. Philos. Prof. Oxon. necnon Inclyti Collegii Londoni et Societ. Reg. Socii, Genev. 1676." In this justly celebrated work, Willis, for the very first time in history, refers defects of the visual field to pathologic alterations in the retina. Despite the fact that, among such deficiencies, he included *muscæ volitantes,* his discovery, or theory, marked a distinct advance in the pathology of the eye.*—(T. H. S.)

Willow salix. A genus of trees and shrubs of the natural order *Salicaceæ,* otherwise regarded as a sub-order of *Amentaceæ.* There are many species and numerous varieties. They are mostly natives of the colder temperate regions of the northern hemisphere, although some are found in warm countries, as *Salix tetrasperma* in the hottest parts of India. The white willow, or Huntingdon willow, is a very rapid grower, and a cutting has been known to become a tree of 30 feet high in ten years, and eventually reaches a height of 80 feet. The wood of some willows is used for many purposes, being remarkably tough and durable, although light and soft. The twigs of most of the willows are very tough and flexible, and are much used for basket-making and other kinds of wicker-work. A valuable medicinal principle called *salicin* exists in the bark of willows; it is more abundant in the Bedford willow (*S. Russelliana*), than in any other species. The weeping willow (*S. babylonica*), a native of the East, is cultivated for its beautiful pendent twigs.—(*Standard Encyclopedia.*)

Many preparations of species belonging to this genus are used in medicine, some of which are quite important in ophthalmic therapeutics.

Of the willow there were eight varieties, according to Pliny the elder. The juice of the leaves and the bark of any of these varieties would seem to have been employed in ancient Greco-Roman times for various affections of the pupils.—(T. H. S.)

Wilson, James. A celebrated blind poet. Born at Richmond, Va., in 1779, he was blinded at the age of four by smallpox, under the following unusual and distressing circumstances. His parents had taken him on a ship, *en route* for England, but, a few days out at sea, both parents died. Shortly afterward, the subject of this sketch contracted smallpox, and, before his arrival in England, was totally blind in one eye and almost blind in the other. Soon after his debarkation he was knocked down by a cow, and, a day or two later, was totally blind.

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* Until Keppler, in the picturesque language of Hirschberg, "cast the lens from its throne and set up in its place the retina" (i.e., as the essential visual apparatus) it was, of course, impossible that the retina should be regarded as in anywise responsible for defects in the visual field. Keppler's discovery was made, or, at least, published, in 1604. See **Keppler.** See, also, **Maurolycus,** p. 7617, Vol. X of this *Encyclopedia.*

The story of the rest of his boyhood and of his youth, is one long tale of almost unvarying sorrow. At the age of eight, however, he was, for a time, self-supporting. Having been presented with a small model of the Royal George, which had just been lost at Spithead, he made a duplicate thereof from a piece of wood "with no other tools than an old knife, a chisel, and a hammer." This duplicate he sold, and soon he was overwhelmed with orders. Still later he carried letters to and from offices some of which were as far as thirty and forty miles apart. He then studied music, but finding that it led to evil associations, he gave that up. He next delivered newspapers to subscribers at a salary of "half-a-dozen papers and two shillings per week." In the course of the last two named employments, he acquired a wonderful knowledge of local topography, as is shown by the following anecdote from his *"Autobiography":* "I hope the account of the following adventure will be acceptable to my readers, as it will illustrate what I have said respecting my perambulations through the town and neighborhood where I was reared. On a winter's evening, in 1797, as I stood in one of the principal streets, I was accosted by a person, who in the southern accent inquired its name. After I had imported the desired information, he told me that he was a soldier, and belonged to a detachment of the Limerick militia, which had marched into Belfast that day.

"'I went out,' said he, 'to look for the sergeant, to get the pay, and being a stranger in the town, I lost myself; I left my wife and my firelock in the lodging-house, and I forgot the name both of the street and of the people that owned the house. I have been wandering about these two or three hours, and nobody can tell me where they are.'

"I inquired if he had observed any particular building near the place where he left his wife. 'I believe,' replied he, 'after turning one or two corners, I observed a church.' I considered for a moment, in which of the streets in that quarter there was a lodging-house, and recollected that a Mrs. Tawny kept a house of entertainment in William Street. I bade him follow me, and took good care to keep before him, that he should not discover that I was blind. At that time there were no houses on the southwest side of William Street; and fronting the houses on the north-east, there was a deep ditch, which served as a receptacle for all the nuisances of the neighborhood. As the night was very dark, and there were no lamps in that direction, his eyes were of no service to him whatever; consequently he resigned himself entirely to my guidance. We had to cross the puddle already mentioned by six stepping-stones; and though there was no danger whatever of being drowned, it was more than probable that, had the soldier got a dip, his plight, on coming out, would have been far different from that in which he appeared at parade. I groped with my staff to the first stepping-stone, and, getting on it, I took hold of his hand, and bade him put his foot where mine was, warning him, at the same time, of the consequence of not balancing well. In this manner I conducted him from one stone to another, till I landed him safely on the opposite side, and was highly diverted to hear him observe that my eyes were better than his. I brought him to Mrs. Tawny's, and left him standing at the door, while I went in to make the necessary inquiry. I soon learned that I had guessed right, for I found his wife almost in despair at his absence, but I bade her to be of good cheer, for I had brought her husband to her; and so saying, I called him in. His wife was rejoiced to see him again, and saluted him, by crying out, 'Bless me, dear Barney, where have you been? I thought you were lost!'—'Arrah, my dear, I couldn't find my way back,' said he, 'if it hadn't been for this decent man that showed me the house.'—'And more shame for you,' said the landlady, 'for you have your eyesight, and yet you must be guided to your lodging by a blind man.' On hearing this they were both astonished, and began heartily to bless themselves. As their astonishment, however, subsided, the hospitality of their Irish hearts began to display itself; for, on discovering that I was only a mortal being, and partook of the same nature and appetite as themselves, I was cordially pressed to stay and partake of the fare that Barney, in all his peregrinations through the streets, had taken good care to bring safely to his wife. I, however, declined the kind offer, and left them to drink their tea themselves, and enjoy the happiness that succeeds when groundless fears and trivial disappointments have vanished away."

After a time, the blind young man turned his attention to the itinerant selling of hardware. Here, too, however, his blindness was very much against him, as witness the following pathetic words: "While vending my hardware through the country, I found this occupation ill-suited to my circumstances; I was exposed to many inconveniences, and experienced much fatigue and distress both of body and mind. The want of sight made it difficult for me to steer my course aright, and I was often exposed both to hardships and danger. Many a time have I heard the thunder roll over my head, and felt the teeming rain drench me from head to foot, while I have unknowingly passed by a place of shelter, or stood like a statue, not knowing which way to turn, though within a few paces of a house. How different then is my situation from his who has his sight! From the impediment which caused me so much pain he is happily exempt; while he pursues his journey, he can trace the various beauties of the surrounding scenery; the picturesque landscape, the spreading oak, the flowing brook, the towering mountain that hides its blue summit in the clouds, the majestic ocean dashing on the 'shelly shore,' and the vast expansive arch of Heaven, bespangled with innumerable stars, have all, for him, their respective beauties, and fail not to awaken pleasing and agreeable reflections; but to the blind these pleasures are unknown, the charms of nature are concealed under an impenetrable veil, and the God of light has placed between him and silent but animated nature an insuperable barrier."

In 1800 he entered a Belfast institution for the instruction of the blind, in which he "acquired a partial knowledge of the upholstery business." This business he followed, it seems, for a number of years with a fair amount of success.

About this time it was that his mind began to turn to literature. Once again we quote from his interesting book: "Time glided pleasantly away, no room being left for idle speculations or gloomy forebodings. In 1803, a number of young men formed a Reading Society in Belfast, and although they were all mechanics, yet some of them were also men of taste, and possessed considerable talents. Into this society I was admitted a member, at the same time that I was kindly exempted from the expense attending its regulations. One of the members was a man of the most extraordinary character I had ever known, and therefore I attached myself to him. To good nature he united an original genius, good taste, and great sensibility; and had an early education been his lot, or had his mind been sufficiently expanded by study, he would have become an ornament to society, but he was totally devoid of ambition, and never had a wish to rise above the rank of an humble mechanic. This man proposed to read to me if I could procure books: our stated time for this employment was from nine o'clock in the evening until one in the morning, in the winter season, and from seven until eleven in the summer; when I was not particularly engaged I frequently attended him at other intervals. At breakfast he had half an hour allotted to him, at dinner a whole hour, and every minute of this was filled up, for he generally read to me between every cup of tea. By this means I committed to memory a vast collection of pieces both in prose and verse, which I still retain, and which have been until the present hour a never failing source of amusement to me. The more I heard read, the more my desire for knowledge increased, while I learned at the same time, that 'the more a man knows, he finds he knows the less.' So ardent and steady was my desire for knowledge at that time, that I could never bear to be absent a single night from my friend; and often, when walking in the country, where I could have been comfortably accommodated, I have traveled three or four miles in a severe winter night to be at my post in time. Pinched with cold and drenched with rain, I have many a time sat down and listened for several hours together to the writings of Plutarch, Rollin, or Clarendon. For seven or eight years we continued this course of reading; but to give a catalogue of the authors we perused in that time, would be far into my present purpose; suffice it so say, that every book in the English language which we could procure was read with avidity; ancient and modern history, poetry, biography, essays, magazines, voyages, travels, etc., were among our studies. How precious these opportunities were, and how dear the recollection of them are to me even now, can only be adequately understood by the few who have realized similar enjoyments, and can indulge in similar recollections. Thus, and otherwise, I was enabled to collect a number of miscellaneous facts in sundry departments of knowledge, but without being in the possession of the links necessary to bind them together, and form them into a connected system. But even as detached facts they were valuable; and when I obtained one fact that seemed new, striking, and important, I felt a thrill to my very soul as if I had found a blessing, and so I had."

The first of Wilson's poems to attract the attention of the public was, "*An Elegy on the Death of an Unfortunate Female.*" Encouraged by this success he published in a small volume a collection of his poems. Its success was immediate, giving to its author a well deserved reputation as one of the first of the English minor poets. The most remarkable poem in the collection, probably, is the one entitled "*Verses on the Richmond National Institution for the Blind in Ireland.*" The last five stanzas of this poem are as follows:

"In vain the twilight shade descends
  In magic softness, pure, serene;
In vain the star of evening blends
  Its dewy light to gild the scene.

"Let infidels presumptuous ask,
With reason's boasted pride elate;
But be the Christian's sacred task,
To cheer his brother's hapless fate.

"Be yours, with liberal hand, to prove
The feelings of a grateful mind;
Be yours, by acts of pious love,
To sooth the sorrows of the blind.

"Be his, to speak the Saviour's name
To hearts that catch the joyful sound;
To kindle pure devotion's flame,
And shed immortal glory round.

"Thus, when the veil of darkness spread
In all the gloom of endless night,
'Let there be light,' Jehovah said,
Creation heard and all was light."

Wilson published a number of works in prose, not one of which, however, gave him half the reputation of his poems.

He married on the 27th of November, 1802, a lady whose name is no longer ascertainable. Among his intimate friends were John Lushington Reilly, of Scarvagh, Dr. Percy, Bishop of Dromore, and the Rev. Henry H. Boyd, a famous translator of Dante.

Wilson died at Birmingham, England, about 1845. The exact date cannot be ascertained.—(T. H. S.)

Wilson's cobalt blue. One of the numerous forms of tinted glass now on the market, intended to protect the eyes from glare or from injurious rays of light. Spectograms comparing this with other forms of protective glass will be found in the *Trans. Ophth. Sec., A. M. A.*, p. 256, 1915.

Wilson's welder's glass. Another of the numerous forms of tinted glass now on the market, designed to protect the eyes from glare or from injurious rays of light. Spectrograms comparing this with other forms of protective glass will be found in the *Trans. Ophth. Sec. A. M. A.*, p. 256, 1915.

Wimpern. (G.) Cilia.

Wimshurst, James (1832-1903). Inventor of an "influence" or electrostatic machine; was born in London, England. He demonstrated the possibility of dispersing and reflecting the Röntgen rays.

Windage, Effects on an eye of. See **War, Ophthalmic Medicine and Surgery in.** An illuminating discussion of the subject is that by McKee (*Canada Med. Journ.*, p. 108, Feb., 1919).

Wind-gauge. (a) An anemometer. (b) A pneumatic pressure gauge. (c) A graduated attachment to the sights of a firearm.

Window glass. As R. E. Danforth (*Scientific Monthly,* p. 537, June, 1919) points out, window glass, that came into common use only 200 years ago, is a factor of prime importance in the evolution of man. Not that glass has had much to do with shaping his body and brain of to-day—it has not had time to do that—but that the thoughts filling his mind, that the greater part of his activities, and that the bodies and brains of generations to come are and will be greatly influenced by window glass; and that in it are serious dangers as well as boons. The thought is astonishing, yet simple of proof, and clear as the light which comes through the windows in question.

Before window glass became a common possession of the people there came into homes and shops the air and the temperature of outdoors through the openings which admitted the light of day. The air was beneficial but the temperature it brought with it not always so. When the outdoor temperature was not too low and the outdoor air not in too great activity, life and industries within could go merrily and well, but let either the air or its temperature be unfavorable and at once discomfort and a necessary cessation of certain activities ensued.

Think of the demoralizing effect of such uncertainty upon industry. Modern inventions could not have come in such marvellous profusion before the day of this one invention of a simple device admitting daylight and excluding to a great extent, the outer temperature.

Many other inventions should do homage to this one to which they unwittingly owe their existence. Even today if window glass should become one of the "lost arts," a large number of other inventions would at once cease to be useful or be forgotten through neglect, even despite the fact that artificial illumination has made remarkable strides since the universal introduction of window glass. When we boast that so many changes have taken place in our industrial life so very recently, and that our so-called "civilization" has had a mushroom-like growth, let us note that the chain of links of causes leads us quickly back to window glass as one of the prime permitters.

But, some one may object, was not glass manufactured and distributed by the ancient Phœnicians? Yes and probably before these by the Egyptians. How then can we attribute our very recent and radical changes to window glass? It is indeed surprising to think how new is the general use of glass in windows when the substance had been known so long and used for vases and gems and, now and then, in some sort of window. We read of ancient windows of perforated marble frames set with small plates of cast glass. There were the marvellous stained glass windows of medieval cathedrals. Back as far as the time of Pope Leo III (795-816 A. D.) and probably earlier, colored glass was used for church windows. The common people, however, had no such luxury in their homes and shops. That which we now consider a necessity, was unknown to our forebears for many centuries thereafter. Recent terrific explosions in New Jersey, breaking windows in many hundreds of homes and other buildings, brought home to some for a few days our real dependence upon window glass today.

By 1302 the king of France used some window glass made in his own country at Bezu le Foret, Department of the Eure. Eneas Silvio, who later became Pope Pius II, expresses his surprise at finding glazed windows in Vienna in 1448. These were probably composed of these strange round panes that are sometimes imitated in modern windows.

Whatever window glass existed in Roman times was cast. The art of casting glass seems then to have been forgotten until 1688, after which it became possible to make much larger mirrors than could be made by blowing. Yet window glass was even then the prized possession of kings and wealthy nobility, and these had only a scant supply.

A writer in the time of Elizabeth speaks of glass windows displacing lattice-work, but so rare and costly was it at that time that some noble when he left his city residence had the glass windows carefully removed. A century later, in the time of Charles II, glass was not used in all of the rooms of the king's palace. It was therefore not before the eighteenth century that glass became at all common in the windows of the people. It seems safe to assume that while many individuals may have had scant supplies of window glass by the middle of the seventeenth century or earlier, the commodity could hardly have been common before the eighteenth century, hence its effect upon human customs, industries and mode of life could not have begun to operate appreciably before that time, and it is with this far-reaching effect upon race evolution that we are now concerned, rather than with the question of when the first European cobbler may have put glass into the window of his shop or home.

Without some of these facts we might easily fall into the error, which is doubtless very prevalent today, that our ancestors had had glass windows a much greater proportion of the time elapsing since the invention of glass so many centuries ago. But the great change in home life and the change in industrial life and in the industries themselves could not begin until an abundance of cheap glass filled all homes with a flood of daylight, and all shops and offices and factories as well, keeping in the artificial heat at the same time. From that time the outdoor life rapidly lost its people while the world of indoors gained devotees, willing or unwilling, by thousands of thousands. A host of new industries sprang into being in the wake of window glass, and these begat other industries, scientific inventions and discoveries with magic rapidity. The general use of window glass is a thing of yesterday, and in its train there now follows a striking pageant of industrial revolutions. Large factories were made possible, big business began and the physical conditions of home life were completely changed. The air which all breathed, in home and shop and office, became at once far less pure, its oxygen was consumed and it became flecked with fine dust, and the pristine rigors of a temperate climate, with all that they had meant for the vigor of the northern peoples, were commuted to conditions of tropical evenness of temperature with what debilitation such brings and without the constant renewal of air which might be had in the tropics. Although this change came but yesterday, already a marked increase in physical debility in our most ''civilized'' populations is a matter of common comment and concern. How quickly our young men in army and navy camps respond to a more rigorous life, with much training in the open under all conditions of temperature and weather. We can fairly see the color and strength and sturdiness return to the youth of a civilization whose vital strength is ebbing while its inventions and industries fairly leap into being.

Before the days of universal window glass what conditions prevailed? There was not the same field for people in the industrial life that there is today, while the very lack of combination and cooperation in commerce and industry made it necessary for a far larger proportion of the population to raise their own food in part, thus the indoor life was not available and the outdoor life was a necessity to a larger extent than today for the majority of the people.

With window glass the habits of life and livelihood are completely changed, habits of thought are revolutionized and the field and scope of thought changed. The whole environment is changed for the species, including temperature, humidity, material environment, composition of air breathed, visual and mental horizons, and a change in the relative adjustments of human beings to disease germs. Such radical changes both within and without the human organism are bound to produce physiological changes in the individuals. They also set in motion new factors in the evolution of the race. Whether we accept the results of experiments like those, for instance, of Kammerer, the Viennese, upon the effects of climatic change upon the germ plasm of animals and their offspring, or whether we reject them as inconclusive, it is certain that climate and other environmental factors always do in the long run change the character of the inhabitants very radically in one way and another, although just how and in what ways may long remain a subject of dispute.

With window glass industry in shop or office can go on without a break caused by the weather, and what is of still greater consequence, without the long winter hiatus during which bright thoughts could be forgotten and the best of intentions could fade away. Most of our industries of today depend upon steady continuity for their existence, and without a guarantee of continuity it would be folly to start many of them. If bad days in summer could stop them and the long cold of winter interrupt them, few of them could be run profitably at all and none of them attain to anything comparable to their modern magnitude.

With window glass man leaves his outdoor or semi-outdoor activity and becomes a modern industrial worker or office server. With a sturdy foundation of outdoor health behind him he may not notice ill effects of degenerating muscles or dust-clogged respiratory tracts, and he may pass on to his offspring for two or three generations a vigorous heredity. This sturdy heredity came from thousands of generations, literally millions of years of outdoor life of the most strenuous sort. From time immemorial man had lived the kind of life which developed strength and hardiness, on the one hand, while, on the other, it weeded out weakness. The heritage of the ages is not lost over night, yet already we note inroads into the health and vigor of the people. Industries indeed evolved prodigiously, but "advance in civilization" is not necessarily human evolution.

How then is window glass a prime factor in human evolution? First, it changes man's environment and changes his field of thought. Secondly, it alters the temperature and humidity of his environment. Thirdly, it gives him air of a different quality and composition to breathe. Fourthly, it compels him to inhale fine dust constantly. Fifthly, it removes out-door activity from all women and most men in "up-to-date" communities. Sixthly, the germ content of the air in confined buildings is greater than normal, especially so in times when colds and other infectious diseases abound. The more frequent illnesses result in impaired health and reduced vigor. The inferior air also reduces vitality. The inhaled dust clogs minute bronchioles and alveoli of the lungs, causing thousands of cells to toil constantly to ingest foreign and insoluble particles. The muscular degeneration consequent to the changed manner of life will make its permanent change in the race of tomorrow; so will the reduced vitality resulting from the causes just mentioned. So also will the complete artificiality of thought and surroundings. The man of the future will be just as surely altered by these things as is the parasite altered by the environment in which it lives. Whether by direct and cumulative effect upon the organism, or whether by indirect selective agencies of one sort or another, environment in time makes all things new. Great care should be given to the kind of life we lead, and to the kind of factors which we allow our new discoveries and our new "civilization" to load upon us, lest we become the slaves and dupes of our enlightenment, even as the parasitic worm is the dupe of his unfortunate host. Great care should be given to the subject of window glass, that we may see to it that we reap the blessings it brings with it and avoid the bane. See, also, **Glass**, p. 5392, Vol. VII of this *Encyclopedia.*

Window-mirror. A mirror so fastened outside a window that persons beneath it may be seen from the interior of the room.

Windsor, John. A distinguished Yorkshire botanist, surgeon, gynecologist, and ophthalmologist. Born in 1787 at Lettle, Yorkshire, he studied in London at St. Thomas's and Guy's, and in 1812 became M.R.C.S. (Eng.). After further study at Edinburgh and London, he settled in Manchester, where he was soon appointed surgeon at the Manchester Eye Hospital, a position which he held for more than 40 years. In addition to a number of articles on gynecologic subjects, he wrote on tumors of the lid and eyeball, ptosis, argyrosis and plumbism palpebrarum, etc. Windsor died Sept. 1, 1868.—(T. H. S.)

Windsor, Thomas. A Manchester, Eng., ophthalmologist, who was born in 1841 and who died April 13, 1910. He was, at various times, editor of the "*Ophthalmic Review,*" surgeon to the Manchester Eye Hospital, ophthalmic surgeon to the Manchester Royal Infirmary and lecturer on ophthalmology at the Owens College. He was a very eccentric man, but kind and magnanimous. He left property appraised at £38,162. In his will was this provision: "I direct my executors to spend as little as they reasonably can on my funeral. I wish no one to be invited and no notice of my death to be inserted in the newspapers. I wish to be cremated, but no extra expense is to be incurred." To his housekeeper, Miss Lily Hargrave, he left, according to the *Ophthalmoscope* for July, 1910, "£2,000, £250 a year, 500 books, and other effects." His residuary estate, which will apparently amount to about £25,000, he directed should be used as a fund for the relief of suffering, stating that nothing should be given to any hospital, medical institution, church, or charity subject to any particular religious body.—(T. H. S.)

Wines. VINA. *Medicated wines* form a class of liquid preparations in which white wine is used as a menstruum. They are all freely miscible in water and in alcohol and although quite similar to tinctures are not so strongly alcoholic. The ophthalmologist is mostly interested in *vinum opii* (q. v.).

Wine was employed in ancient Greco-Roman ophthalmology chiefly as a menstruum. It was also regarded, however, as a very active ophthalmic medicament. Thus, the juice of unripe grapes, called omphacium, was highly esteemed as a remedy for trachoma ("rough spots upon the eyelids"). Wine vinegar, also, according to Pliny, was a strengthener of the eyes. Falernian wine, according to the same authority, "is productive of injury to the sight"; but, in general, wine, if used in moderation, was esteemed by the ancient Greeks and Romans as a clarifier and strengthener of the vision. The harmful effects upon the eyes of the excessive use of wine, was a matter, then as now, of common observation.—(T. H. S.)

Wing test. See p. 4688, Vol. VI of this *Encyclopedia.*

Winkel. (G.) Angle.

Winking. See **Nictitation**, p. 8371, Vol. XI of this *Encyclopedia.*

Winking centre. The reflex centre for winking, in the medulla oblongata.

Winking, Jaw—. In addition to the matter under **Jaw-winking** and on p. 649, Vol. I of this *Encyclopedia,* it may be added here that the following reviews of this curious phenomenon are from the *Am. Journ. of Ophthalm.,* Oct., 1918.

In the case reported by Demaria and Caldora in which, during rest, a slight ptosis existed of the right eye, this anomaly disappeared and even left exposed a part of the sclera above the cornea, when the inferior maxilla was drawn downward in mastication. The elevation of the upper lid attained its maximum when the jaw was moved laterally in the direction opposite that of the affected eye. The other ocular muscles were normal though the pupil was larger than that of the other eye. The most general opinion of the cause of this condition is that the nucleus of the oculomotor is congenitally related to the trigeminus and even the facial. Lutz, however, opposes this view and thinks that the anomaly must be referred to the subcortical center. On the ground of the anisocoria observed in their case, the reporters believe that the cause must reside in the cortical centers, near the lower part of the frontal convolutions, which are probably connected by Meynert's U fibers.

In Holloway's case of a woman aged 44, there was a history of distinct drooping and retraction of the right lid at times, or as the patient expressed it, "she winked when she ate." This was first noted by her mother when she was a nursing infant. While the palpebral fissure measured 9½ mm., she stated that at times the right upper lid drooped. The eyes fixed well in various positions, except above the horizontal plane, when the right eye diverged. There was a suggestion of lagging in the upward rotation of the right eye. Upon looking downward the right upper lid failed to follow the globe to the same extent as the left upper lid. Upon attempts at chewing, there was retraction upward of the left upper lid, accentuated upon labial movements of the jaw. This retraction was excessively marked when the patient looked down; and but slight when she looked upward. The diplopia fields indicated paresis of the right superior rectus. The eyes were otherwise normal.

In Kleinhans's case with complete congenital ptosis of the right lid, upon opening the mouth the lid shot up. Lateral movements of the jaw had no effect upon the lid. There was insufficiency of the right superior and internal recti, no fundus changes, and vision in each eye was normal.

Menacho observed retraction of the upper lid associated with lowering of the lower jaw, but not with its lateral movements, as in most of the cases published, in a healthy young woman presenting simply a slight enlargement of the thyroid, without any of the other symptoms of Graves' disease; the association was first noticed when the patient was 12 years of age. How may we explain the connection between the third and fifth nerves, in this case, acquired and not congenital? The writer believes an exclusively anatomic explanation of this phenomenon to be unjustified. He argues that a close relationship exists between the functions of the cranial nerves—a relation which may be attributed to connections situated at the nuclei of origin, between the subcortical centers, or in the cortex itself. These paths of communication, regarding whose precise course physiology and anatomy have still something to clear up, may be functionally interfered with, either by inhibition or irritation; this hypothesis explains provisionally the phenomena presented by this case. A purely anatomic hypothesis would be quite justifiable if the condition had been congenital but meets with an insuperable objection where it is acquired.

In Schirmer's case a healthy man aged 28 years developed a left-sided facial paralysis seven months before; after four months slow but continuous improvement began. Recovery perfect except for a slight weakness of all the muscles innervated by the seventh nerve. For more than three months, every movement of the left cheek, in laughing and chewing, was accompanied by partial closure of the left eyelids. Spontaneous contractions of the left orbicularis were not present. The reporter thinks that these associated movements are due to the fact that from the central stump of the facial nerve, fibers which were meant for the muscles of the cheek have grown into the orbicularis muscle. Every intended movement of the cheek will therefore be accompanied by contraction of the lid muscle. This explanation was first given by Lipschitz.

Gonne observed a case which he considers to be an instance which has hitherto been described in the Italian literature alone under the title ''ptosi bilancia''—balance ptosis. The patient was an adult male, the subject of lues, who developed ptosis of the left eye, and the left eyeball showed a slight divergent strabismus. The inward rotation of this eyeball was impaired, but other extraocular movements of both eyes were normal. The right pupil reacted promptly to light, the left sluggishly. When he closed the right eye, the left upper lid raised without effort, and the eye was opened to almost the full extent. With the right eye opened the left could not be raised at all. There was no facial palsy or asymmetry, and the tongue was protruded straight and showed no atrophy.

There were a number of other neurologic symptoms of syphilis of the nervous system, a positive Wassermann reaction in the spinal fluid. Well marked disseminated choroiditis, probably specific, was also present. The case evidently showed incomplete paralysis of the left third cranial nerve, manifesting itself as balance ptosis. It is quite similar to the case of ''ptosi bilancia'' reported by Artum in *Il Polyclinico Practica*, 1913, in which the diagnosis of syphilitic basilar meningitis was made. The same symptom was reported by Pacetti in three cases of tabes and taboparesis. In none of these cases was the spinal fluid examined.

This peculiar type of ptosis may be looked upon as a sign of syphilis of the central nervous system. It might be thought to be due to the reflex action on the part of the patient to prevent diplopia, but one objection to this view is that in a reflex closure of the eye, there is spasm of the orbicularis palpebrarum, which is not supplied by the third nerve, but by the facial. There was no indication of facial spasm in this case. Another objection is that although diplopia is common, a balance ptosis is extremely rare.

In the discussion of this paper, Clay advanced the plausible explanation, that the paretic left lid could be raised when the right eye was closed by reason of an increase of nerve supply to the partially paralyzed levator. This was the original explanation also of Pacetti, though this hypothesis involves a theory of the relations of the oculomotor nuclei which is not altogether clear, as observed by Camp in the course of the same discussion.

Winking, Reflex. Reflex blinking. The "reaction-time" is the period that elapses after light or other stimulus has occurred until a movement is made. The time of the reflex act of winking is, according to Exner, about 0.06 second.

Liepmann and Levinsohn (*Ophth. Year-Book,* p. 290, 1913) report two cases of complete blindness following apoplexy, one of which retained the winking reflex to light stimulation, while the other did not. In each case there were two strokes, in one of which the right optic radiations were broken through, while in the other the calcarine area was destroyed. The pupillary reflex was retained in both cases. In the patient who retained the winking reflex a typical closure of the lids was had with relatively weak illumination. Liepmann refers to previous animal experiments, in which abolition of the winking reflex was produced by destruction of the external geniculate body, or of the centriped lid fibers situated in the depth of the anterior corpus quadrigeminum.

Winslow, Jakob Benignus. One of the greatest anatomists of all time. Born in Denmark, April 2, 1669, he studied at first theology, but was led to medicine later through association with one of his youthful friends, a medical student. In the course of his professional studies, he was given financial assistance by the King of Denmark until the young Winslow became a Catholic. He was graduated in 1705 at Paris. Here he settled and soon became a Fellow of the Academy of Science and a Professor of Anatomy. After many long years as a teacher and investigator, he died April 3, 1760, aged 91.

Many parts of the human body are called today by the name of this great anatomist—*e. g.,* foramen Winslowii.

His most important work was entitled *"Anatomical Exposition of the Structure of the Human Body"* (3 vols., Paris, 1732; numerous later editions and translations). Other books of Winslow's were: *"Observations on the Fibers of the Heart and on the Valves, with the Manner of Preparing them for Demonstrations"* (Paris, 1711); *"Description of a Singular Valve in the Vena Cava and a New Idea on* *the Famous Question of the Foramen Ovale"* (Paris, 1717): *"Light upon the Circulation of the Blood in the Fœtus"* (Paris, 1725).

Regarding his ophthalmic writings, Winslow, among other observations, took the position that the iris is convex forward, and that this convexity increases as the pupil narrows, and diminishes as it widens. This is due, for the most part, to the fact that it lies and glides upon the surface of the lens.

He was also the first to point out that the center of the pupil does not lie precisely opposite the center of the cornea, but a little to its inner side.

In 1721 Winslow proposed that the word, "iris," be applied to the structure which, today, bears that name universally. Until that time, the part in question had been known as the "uvea." The word, "iris," had been employed as an ophthalmo-anatomical term before the days of Winslow. It was used by Galen, for example, to signify the "ciliary body," and, by Rufus, for the anterior surface of what today is called the "iris."—(T. H. S.)

Winter bloom. See **Hamamelis,** p. 5691, Vol. VIII of this *Encyclopedia.*

Wintergreen. CHECKERBERRY. TEABERRY. The leaves of *Gaultheria procumbens* furnish a fragrant volatile oil containing much methyl salicylate. This oil is a favorite in the treatment of "rheumatic" complaints in doses of 3 to 10 minims. As in the case of other *salicyl* preparations it has been charged with the production of sudden blindness.

Winther, Ludwig Franz Alexander. A celebrated surgeon of Giessen, Germany, of considerable ophthalmologic importance. Born at Offenbach-on-the-Main, Mar. 9, 1812, the son of a well-known military surgeon, he received his professional degree at Giessen in 1837. Almost immediately he was made assistant to Balser at the Giessen Medico-Ophthalmologic Hospital. In 1841 he studied at Paris and Vienna, and, returning to Giessen, qualified as privatdocent there in 1842. In 1848 he was made extraordinary, and in 1867 ordinary, professor of pathology and pathological anatomy. For a number of years he delivered a special course of lectures on ophthalmic operations. He died April 26, 1871.

Aside from works of a general character, he wrote: 1. *Untersuchungen über den Bau der Hornhaut und des Flügelfelles.* (Giessen, 1856.) 2. *Lehrbuch der Augenheilkunde.* (Giessen, 1859.) 3. *Experimentalstudien über die Pathologie des Flügelfelles.* (Erlangen, 1866.)—(T. H. S.)

Wire micrometer. A micrometer of which the field is traversed by fine wires, arranged in parallel and intersecting series.

Wire optometer. VON GRAEFE'S OPTOMETER. See p. 9101, Vol. XII of this *Encyclopedia*.

Wirklicher Brennpunkt. (G.) Real focus.

Wise and Illustrious, The. See **Avenzoar.**

Witch hazel, Extract of. See **Aqua hamamelidis,** p. 543, Vol. I, and p. 5691, Vol. VIII of this *Encyclopedia*.

Withania somnifera. A plant recommended as a hypnotic; it is nearly related to *Atropa belladonna*.

Witness, The ophthalmic expert. See **Legal relations of ophthalmology,** first third of the section.

Witt, Gisbert de. An Amsterdam surgeon of the later 18th century, who wrote an unimportant work on the cataract operation. This brochure of 130 pages was entitled "*Vergleichung der Verschiedenen Methoden den Star Auszuziehen*" (Giessen, 1775).—(T. H. S.)

Wittelsbach, Carl Theodore, Duke of Bavaria. A member of the royal family of Bavaria, who became a world-renowned ophthalmologist. Born Aug. 9, 1839, at Possenhofen, the second son of Duke Max of Bavaria, he was also a relative of the "mad King of Bavaria" (who committed suicide by drowning in a lake), brother of the Empress of Austria (who was assassinated at Geneva), and uncle of the Austrian Crown Prince (who died under mysterious circumstances). At first he served in the Bavarian artillery, but later he began to study medicine in spite of the "well-nigh insuperable difficulties thrown in his way by his family, who did not regard medicine as a profession suitable for a Grand Duke."* He studied at Mentone, at Zürich, and at Munich, at the last-named institution receiving the honorary degree of M. D. in 1872. Eight years later, a special decree was issued by the imperial chancellor, Bismarck, granting to the Duke the right to practice medicine.

He then settled as ophthalmologist at Tegernsee, in the Bavarian Alps, and was at once successful, in the highest meaning of the word. Despite, however, his crowded "Ducal clinic," he spent two months each year, from 1880 till 1888, in special study at Vienna. His first wife, Sophia, a daughter of King John of Saxony, having died some years before (about the time when he first began to study medicine) he took as his second consort (in 1874) Maria Jusepha, of Portugal, a Princess of Braganza—a most estimable lady, who, like her husband, became enthusiastic about medicine, and was, for a long time, his chief assistant. At the "Ducal clinic" thousands on thousands of the poor were treated, fed and housed gratuitously, and, in addition, very often sent away with a little purse of money. Altogether, "Duke Carl" is said to have performed more than 7,000 cataract extractions.

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* "So many of us," said the Duke, "are soldiers, whose business it is to kill, that it is high time some of us took to curing."

The Duke was honored, as a matter of course, in very many ways, but, in spite of his royal rank and high social prestige, he was truly deserving of all the honors which were conferred upon him. When the Kaiser's eye was injured by a rope on the royal yacht, the Hohenzollern, Duke Carl was made the attendant in the case. Honorary degrees were conferred upon him by the universities of Louvain and Brussels, and by other universities. The Duke was a man of great personal influence, or "magnetism," and had the happy faculty of inspiring almost all who came within his presence with an overwhelming enthusiasm for the healing art. To this fortunate faculty it is that the Medical School of Harvard University owes the Lowell devise—lands left to this institution by a Miss Lowell, a milliner in Boston, who had been a patient of Duke Carl's.

This truly "noble Duke," after a life of charity and mercy toward others, entered into rest Nov. 30, 1909. He was buried in the castle church at Tegernsee. The cause of the death was chronic Bright's disease.

Among the more important writings of Duke Carl, we may mention: 1. Untersuchungen über die Anhäufung Weisser Blutkörper in der Hirnrinde. (Virchow's *Archiv,* LXIX.) 2. Ueber den Einfluss der Temperatur der Umgebenden Luft auf die Kohlensäureausscheidung und die Sauerstoffaufnahme bei einer Katze. (*Z. f. Biol.,* XIV.) 3. Beiträge zur Anatomie und Pathologie des Glaskörpers. (*Arch. für Ophthalmologie,* XV.) 4. *Ein Beitrag zur Pathologischen Anatomie des Auges bei Nierenleiden.* (With 12 illustrations, Wiesbaden, 1887.) 5. *Beitrag zur Cauistik der Orbitaltumoren.* (Munich, 1886.)—(T. H. S.)

Wodan. (In Southern Germany, Odin.) In old Germanic mythology, the great Allfather in general, and the god of battles in particular. He was armed with his war-spear Gungnir, which seems to have been identified with the lightning flash. Wagner: "He gave his eye in pledge to the wise giant, Mimir, at Mimir's Well, for a draught of primeval wisdom."—(T. H. S.)

Woerde, Nicaise de. A famous blind priest. See **Werde, Nicaise de.**

Wohlfartia magnifica. The larva of this fly is most frequently responsible for "fly-blown" orbit. See **Orbit, Myasis of the,** pp. 9145 and 9350, Vol. XII of this *Encyclopedia.*

Awad Barsoum (*Bull. Ophthalm. Soc. of Egypt,* p. 64, 1917; abst. *Br. Journ. Ophthalm.,* p. 379, Aug., 1919) refers to the account

(1915) of Azer Wahba, detailed in the sections just referred to. Barsoum describes three other cases, also in children. The larvæ removed from Barsoum's cases were sent to Dr. Lewis Gough, who bred from them a sarcophagidal fly identified as Wohlfartia magnifica Schinner, which is said never to enter houses. On the other hand, in Wahba's cases the condition was due to Cordylobia anthropophaga.

Briefly, the details of Barsoum's cases are as follows: 1. A child of two years was affected with sloughing and much swelling of the lids of one eye. The condition gave rise to a most offensive odor, and "larvæ dropped from the region of the eye as the child walked through the out-patient shelter." One hundred worms were taken away. The mesial halves of both lids were destroyed. There was a large pocket, packed with worms, between the eyeball and the nose, and two other pockets, also filled with larvæ, were found, one on the upper aspect and the other on the outer side of the globe. The condition was treated by constant bathing with sublimate (1 in 5,000) and by fomentations of potassium permanganate (1 in 4,000). On the second day, the eyeball was eviscerated, and large maggots were removed from behind the globe. Child died on the third day. No autopsy. 2. A child, aged one year, had a notch, about 7.5 mm. in diameter, near the inner canthus of the right upper lid, from which five worms were picked and two others were found free in the conjunctival sac. Recovery. 3. A child of three years showed ulceration of the left orbital region near the outer canthus, and from this three pockets full of larvæ extended, one towards the lower lid, a second towards the temple, and a third towards the inner canthus. Recovery.

Wolf. The dung of the wolf was often used for "suffusio," as cataract was called by the ancient Roman physicians. Wolf-grease, furthermore, was employed as a salve in blepharitis marginalis.—(T. H. S.)

Wolfe graft. See **Grafting,** p. 5628, Vol. VII; also **Plastics,** p. 10255, Vol. VIII of this **Encyclopedia.**

Wolfe, John Reissberg. A celebrated German-Scotch ophthalmologist, inventor of Wolfe's refracting ophthalmoscope. Born at Breslau, Germany, in 1825, he received the degree of M. D. at Glasgow University in 1856. During the Sicilian campaign he served for a time as surgeon to Garibaldi. Returning to Scotland, he was appointed ophthalmic surgeon to the Royal Infirmary, Aberdeen. Removing thence to Glasgow, he founded the Glasgow Ophthalmic Institute, and was the first professor of ophthalmology at St. Mungo's Medical School, Glasgow. At the age of 78 (i. e., in 1893) he emigrated to Australia, where he remained for about eight years, during which time he was surgeon-oculist to the Governor of Victoria, Lord Hopetoun. Returning to Glasgow about 1901, he lived there in retirement until his death in 1905.

Wolfe's main ophthalmic writing was, "*On Diseases and Injuries of the Eye: A Course of Systematic and Clinical Lectures.*" (p. 452, London, 1882.)—(T. H. S.)

Wolffberg, Test-type of. See **Test chart.**

Wolff-Eisner reaction. See **Calmette's ophthalmo-tuberculin reaction,** p. 1361, Vol. II of this *Encyclopedia.*

Wolff, Philipp Heinrich. A well-known German poet, otologist and ophthalmologist. Born at Berlin, May 2, 1813, he studied at Berlin and Bonn, at the latter institution receiving his degree in 1836. He is sometimes said to have invented subcutaneous tenotomy for strabismus. The honor, however, belongs to J. Guérin. Wolff was merely the first to perform this operation with scissors, instead of with Guérin's knife.

Wolff died Nov. 6, 1886.

In addition to works on general medicine and otology, he wrote "*Neue Methode des Schielauges durch Subcutane Tenotomie*" (Berlin 1840). At a writer of poetry he employed the pseudonym, *Ernct Waller.* He composed a very large number of poems, many of which were tragedies.—(T. H. S.)

Wolfram. See **Tungsten.**

Wolfskirsche. (G.) Belladonna.

Wollaston's prism. A double-image prism (q. v.), in which the emergent rays are equally deviated on opposite sides of the normal at the point of incidence. It consists of two right-angled prisms of calcite (q. v.), or quartz, cemented together so as to form a prism of rectangular section, in which the optic axis of the first prism is parallel to the incident face, and in which respect only it differs from Rochon's prism (q. v.). Hence, it is Rochon's prism turned through a right angle when exposed to incidence.—(C. F. P.)

Wollaston, William Hyde (1766-1828). English chemist and physicist, born in East Dereham, Norfolk. Starting practise as a physician, he subsequently devoted himself wholly to science. His researches were pre-eminently fruitful in the departments of chemistry and optics. Amongst his important discoveries were two new metals, palladium (1804) and rhodium (1805). By his ingenious method of rendering platinum malleable he made $150,000; and some other practical discoveries were also highly lucrative, such as the method of drawing very fine wires.

His contributions to optics were the reflecting goniometer, the camera lucida, the discovery of the dark lines in the solar spectrum, and of the invisible rays beyond the violet, and an immensity of valuable observations on single and double refraction. He did much to establish the wave theory of light.

See his thirty-nine memoirs in the *Philosophical Transactions* (1809-29), and a sketch of his life in George Wilson's *Religio Chemici* (1862).—(*Standard Encyclopedia.*)

Women, Diseases of. The ocular relations of diseases peculiar to the female sex are discussed under various headings; for example, **Climateric**; **Menopause**; **Pregnancy**; **Menstruation**; **Lactation**; **Uterine**; **Ovarian**, etc.

Wood alcohol. See **Alcohol, Methyl,** p. 214, Vol. I; **Conservation of vision,** p. 3253, Vol. V; p. 2510, Vol. IV, as well as under **Toxic amblyopia.**

In addition to this material it may here be added that an example of unilateral retrobulbar neuritis from wood alcohol poisoning is reported by H. W. Cowper (*Ophthal. Record,* September, 1916). The patient was a woman, aged 35, who had been an alcoholic for years. About the end of February, 1916, she drank wood alcohol. Over a period of two weeks she took a "couple of swallows" on five or six occasions, thinking it was gin. There was no doubt as to its having been wood alcohol. On the day after she took the last "swallow" she became weak, dizzy, and of uncertain gait, and that evening there was a violent attack of vomiting. The next three days she was confined to her bed and seemed so ill that her friends had the last rites of her church administered to her. A few hours after the attack of vomiting she first noticed disturbance of her left vision. She describes it as though black strips were in front of the eye. Very soon this was followed by definite blurring. After a few days the vision improved, but the improvement lasted only a short time when the vision again became worse. Her right eye was never subjectively affected. There never were acute abdominal symptoms such as violent pain or diarrhea.

Cowper saw her for the first time in this present illness on April 18, 1916. R. V. was 20/20, L. V. 20/200. Pupils were equal and active. Ophthalmoscopic examination was negative except that the temporal half of the left nerve was paler than that of the right. During the next two or three weeks the atrophy became well marked and the vision diminished to counting fingers at three feet. The fields taken three months after the poisoning showed in the right no abnormality except possibly slight contraction of the blue and red. In the left there was no contraction of the white but a definite concentric contraction for the colors and a scotoma extending from the fixation point to the blind spot. Upward and inward the scotoma extended not at all beyond the fixation point while downward it went five degrees and outward fifteen. The scotoma was absolute. Fields were taken in a moderately bright light with one centimeter square colors. Fields for yellow and green were not taken, but it was determined that there was no central scotoma for green in the right. Urine examinations were negative as also one Wassermann. A nasal examination was made for the especial purpose of excluding if possible sinus trouble, but no abnormal condition was found.

The writer had examined reports of over 200 cases of wood alcohol amblyopia and there was not one in which one eye escaped. This case is possibly unique in that respect and consequently worth reporting.

In many of the cases reported one eye was more seriously damaged than the other. Any explanation accounting for this selective action would apply equally well to such a case as the above.

G. V. A. Birch-Hirschfeld (*Med. Klinik,* Feb. 27, 1916) has given a full account of the damage to the ocular apparatus by the ingestion of methyl alcohol, in an article reviewed in the *Journ. Am. Med. Assoc.,* April 22, 1916.

The writer says that quite a number of cases of methyl alcohol poisoning have occurred recently in soldiers, and not infrequently it has entailed severe and permanent injury of the eyesight. He has compiled a total of 235 cases, not including those that terminated fatally before the eyes were examined. He refers to the 163 cases of poisoning from methyl alcohol at the Berlin municipal lodging house, when seventy-two persons died and four were left permanently blind. This experience is recalled to show the difficulty of differentiating the trouble, as the symptoms were ascribed to meat poisoning at first. A number of lives would have been saved if the true cause had been suspected earlier. He reports two cases of blindness from this cause he has recently encountered, in one case proving permanent. In the other case vision improved to 6/18 and the fundus findings grew normal. Patillo has described two cases in which blindness came on four or fourteen days after varnishing the inside of beer casks with varnish dissolved in methyl alcohol. Inhalation of the fumes was evidently responsible in these cases, and Hirschfeld thinks this was a factor in the cases attributed by Wood and Buller to absorption through the skin. The symptoms do not develop until after several hours or days, and then involve the digestive apparatus, with nausea, dizziness, vomiting and headache, progressing rapidly to delirium and convulsions. Usually vision becomes impaired before the general symptoms mask the clinical picture. The dilated rigid pupil suggests impending trouble. If the ophthalmoscope reveals optic neuritis, this is a clue to the diagnosis, but it has no pathognomonic features. At the same time, methyl alcohol poisoning should always be suspected when, along with gastro-intestinal symptoms suggesting poisoning, severe disturbance in vision develops suddenly, with central absolute scotoma and contraction of the peripheral field of vision, and the ophthalmoscope shows optic neuritis. The contraction of the peripheral field of vision usually subsides soon, but the scotoma may persist a long time. The prognosis, he thinks, can be estimated from comparison of the findings in the visual field and fundus, and the visual acuity for a few weeks. So long as the visual field keeps enlarging, the process of recuperation is not ended, as also when the absolute scotoma changes to a relative. Even in the mildest cases, more or less impairment of vision is entailed, resembling the symptoms of chronic alcohol-tobacco amblyopia. Disturbances in vision from quinin, atoxyl and arsacetin are by limitation of the visual field, central vision persisting good. With meat and fish poisoning the eye is affected by paralysis of the muscles. Male fern amaurosis alone seems to present the same symptoms as those from methyl alcohol. The ophthalmoscopic findings with uncomplicated uremic amaurosis are normal. He regards the fate of the eyes with methyl alcohol amaurosis as usually sealed by the time the patient reaches the physician, and is very pessimistic as to benefit from any measures in treatment. The main point is to recognize its nature promptly and ward off similar injury to others that may be exposed. Promptly seeking out the source and energetic measures may avert much further harm. The methyl alcohol induces rapid degeneration of the nervous apparatus of the eye, affecting the cones of the retina more than the rods, the same as ethyl alcohol, nicotin, thyroidin and carbon bisulphide, while atoxyl and allied substances affect the rods while sparing the cones. There is nothing to indicate inflammatory infiltration in either type.

In this country, in spite of the efforts of State and Federal authorities in conjunction with the endeavors of national societies for the prevention of blindness to prevent the potable use of wood alcohol preparations, deaths and blindness from this poison still continue. Until the authorities see their way clear to prohibiting the general sale of Columbian Spirits and similar poisonous preparations of methyl alcohol, both wholesale and retail parcels of this agent should at least bear a conspicuous poison label.

It seems strange that the laity still persist in buying and using a deadly poison, when an innocuous substitute, namely, industrial alcohol, which answers every purpose of the lethal Columbian Spirits, can be had just as easily and, as a rule, more cheaply.

As an illustration of the wood alcohol intoxications generally going on in this country, the following extract from a local newspaper has been sent the Editor by Dr. E. C. Ellett, of Memphis, Tenn. In this case the substitution of wood alcohol for ethyl alcohol as a bay rum solvent was the cause of the tragedy.

"Conway, Ark., March 31. (Spl.) 1916.—Two men are dead and one is dying in a local hospital as the result of a night orgy in bone dry territory in which bay rum played the principal part, a quart of the poison having been consumed by the three at a party in Andy Francis' barber shop. The dead are Homer Lewellyn and Orfie Douglas, both chauffeurs.

The third member of the party is Andy Francis, the host, who, according to physicians, has practically no chance for recovery. He rallies at intervals and then collapses, and news of his serious condition has not been communicated to his wife.

Lewellyn was the first of the two to succumb to the fatal effects of the wood alcohol, which, it is said, had been ordered by Francis for the party. It is understood that a half dozen were in the barber shop when the drinking began, but so far only four are known to have suffered ill effects, the other members having quit the party without drinking.

Lewellyn and Douglas were found in a critical condition. They never regained consciousness. Accidents kept two other men who had been invited from attending the feast. Substitution of wood alcohol for grain alcohol in the composition of the bay rum is given by physicians as the cause of the tragedy."

A report from the Illinois Society for the Prevention of Blindness says that the Wood Alcohol Bill, presented by the Hon. Wm. G. Thon to the Legislature of the State of Illinois and to which the Society added an Amendment requiring that all forms of wood alcohol, and substances containing wood alcohol be labeled "Poison" with skull and cross bones, was allowed to become a law (1917) without the signature of the governor.

Wood's filter. See **Dazzling, of,** p. 3778, Vol. IV of this *Encyclopedia.*

Woodward, Julius Hayden. A well-known ophthalmologist of Burlington, Vt., and of New York City. Born at Castleton, Vt., May 31, 1858, son of a physician, Adrian Theodore W., and Lois Cornelia (June) W., he received the degree of Bachelor of Science at Cornell

University in 1879, that of Doctor of Medicine at Columbia in 1882, and the *ad eundem* at the University of Vermont in the same year.

From 1884-89 he practised at Brandon, Vt., then removed to Burlington, and, eight years later, to New York City.

He was professor of laryngology at the University of Vermont School of Medicine in 1886, of materia medica and therapeutics from 1887-94, and of the eye, ear, nose and throat from 1890-97. In 1908 he was elected professor of ophthalmology at the New York Post Graduate Medical School and Hospital, and became the head of the department in the same institution in 1913. Both of these positions he held until his death. He was a fellow of the New York Academy of Medicine, a member of the American Academy of Ophthalmology and Oto-Laryngology, and a life member of the Societé Francaise d'Ophtalmologie, Paris.

Woodward wrote a considerable number of ophthalmic articles, the most important of which is "Vision and Audition in Their Medico-Legal Relations" (Witthaus and Becker's *"Medical Jurisprudence, Forensic Medicine and Toxicology,"* 1896).

Dr. Woodward was an athlete, and a member of the New York Athletic and Campfire clubs. He died at his home, 200 W. 58th St., New York City, July 2, 1916.—(T. H. S.)

Woodyatt, Wm. H. One of the best-known and most successful operators among the early ophthalmic surgeons in Chicago. Born in 1846, he graduated from the Cleveland Homeopathic Medical School about 1866. He then spent two years in New York in attendance upon the various eye and ear clinics, and was a student under Herman Knapp for most of the time at the New York Ophthalmic and Aural Institute. He also graduated from the New York Homeopathic Ophthalmic College. Settling in Chicago in the early part of 1870, he almost at once acquired a large practice. He gave a good deal of his time to the teaching of ophthalmology and otology in Hahnemann College until about 1874. Then, with Dr. Charles Adams and others, he formed the Chicago Homeopathic College, in which he worked and taught until his death on the 31st of January, 1880.

Having the advantage of a preparation in the best colleges of both systems of medicine and having been endowed with unusual qualities, Dr. Woodyatt was known far and wide and was regarded as one of the most reliable diagnosticians and operators in the west.—(T. H. S.)

Wool-fat, Hydrous. See **Lanolin**, p. 7011, Vol. IX of this *Encyclopedia.*

p. 11

Woolhouse, John Thomas. A celebrated ophthalmologist of the late 17th and early 18th centuries, and one of the greatest charlatans of all time. He was born in England about 1650 1750, the son of an ophthalmologist, studied at Oxford, Cambridge and at several of the medical centers of continental Europe. He became oculist to James II, and followed this king into exile at Paris in 1788. In Paris he practised ophthalmology for many years, acquired an extensive clientele, and became not only a skillful operator and renowned teacher, but a quack of the deepest dye. For example, he boasted of having secret medicines and operations which he taught to an inner circle of his students for a large financial consideration. A few of his secret procedures he kept entirely to himself. He acquired considerable celebrity by his bitter opposition to "the new doctrine concerning cataract," recently propounded (and at length successfully defended) by both the young Brisseau and the older Maître Jan. The new doctrine was that a cataract consists of an opacity of the crystalline lens, and not of a "thickened humor," or "membrane," in a (purely imaginary) cataract-space between the pupil and the lens.

Woolhouse's most important compositions are: 1. *Expériences des Différentes Opérations Manuelles et des Guérisons Spécifiques qu'il a Pratiquées aux Yeux.* (Paris, 1711.) 2. *Diss. Savantes et Cistiques sur la Cataracte et le Glaucome.* (Paris, 1717.) 3. *Avis de M. de Woolhouse sur une Nouvelle Aiguille à Cataracte qu'il a Inventée et par le Moyen de laquelle il Abat Facilement Toute Cataracte Adhéhérente du Côté de la Tempe.* (Paris, 1720.) Mémoire Communiqué sur la Quantité d'Humeur Aqueuse Contenue dans Chacune des Deux Chambres Comprises entre la Cornée et le Cristallin. (*Jour. des Savants,* 1720.)

Late in life he returned to England, where he died in 1730.—(T. H. S.)

Woolsorter's disease. Anthrax. See p. 512, Vol. I of this *Encyclopedia.*

Woorali. Woorara. Same as curare.

Woorara. Curare.

Word-blindness. Verbal amnesia. See p. 1198, Vol. II; also **Visual aphasia; Alexia; Agraphia,** also, **Amnesia,** and similar captions in this *Encyclopedia.* Here it may be said, in addition, that, of the earlier reports of this disease, Peters (*Oph. Year-Book,* p. 268, 1909) has recorded a case of congenital word-blindness. The patient was a boy of 12, who had been kept 4 years in the same grade with difficulties of reading. In another boy of 11, a case of microcephalic idiocy, Peters discovered something of the same defect. He thinks that it may frequently occur where other congenital deficiencies tend to mask it.

A peculiar case of mind-blindness is reported by Bielschowsky. The vision in one eye was normal. In the other 2/5 with hyperopic astigmia. Objects could not be recognized. There was disturbance in the perception of depth, and micropsia. Bielschowsky thought that double hemianopsia could be excluded.

Russell reports a case of fatal abscess in the angular gyrus and posterior part of the first temporal convolution causing alexia, word-blindness, some object-blindness and partial word-deafness.

Pritchard in 1912 records a case of intermittent word-blindness. A boy of eight years was retarded wholly by inability to learn visual reading. Tested on four different occasions he never recognized more than one or two letters in the alphabet. But his teachers, and a sister who taught him at home, stated that at times he could recognize all the letters and read quite intelligently. Such lucid moments occurred once or twice a week. He had normal vision and could read Arabic numerals correctly. The character of his condition appeared to be allied to neurasthenia or psycho-asthenia.

J. Hinshelwod (*Lancet*, Aug. 17, 1912) discusses the treatment of both acquired and congenital word-blindness. He believes that the old idea that nothing can be done for the education of persons suffering from these serious defects is wrong, and that much can be done if the treatment is conducted on proper lines. Pure cases of acquired word-blindness almost always come to the ophthalmic surgeon in the first instance, as it is supposed that the defect lies in the eyes. The lesion, however, is either in the brain, in the angular gyrus itself, or it is due to the interruption of the communicating fibers between it and the ganglia. In right-handed people the lesion is on the left side.

The writer relates the case of a man, aged 58 years, who awoke one morning with the power of reading quite lost. He had right lateral homonymous hemianopsia, but no other symptoms were discoverable. He started to reëducate himself, learning letters and words like a child. After six months he was able to recognize the letters of the alphabet, but never learned to read words by sight. He could read only by spelling words out letter by letter and thus stimulating his auditory memory. After a year, he gave it up as hopeless; still he had reacquired the visual memory of the letters and of a few short words.

Another patient was a woman, aged 34 years, who had been completely word- and letter-blind for fourteen months; she had right homonymous hemianopsia. A schoolmaster took great interest in her reëducation. It was found that the effort of education was very great, and could not be continued for more than 10 minutes at a time. Ultimately she learned to read simple Bible texts by spelling out the words. Her progress had been steady but slow from that point of attainment; but after an interval of ten years she could read a newspaper fairly fluently, only occasionally she was compelled to spell words.

The third case was that of a girl, aged 14 years, who had had right-sided paralysis and loss of speech 18 months before. Previously she had been a good reader. When first seen she was completely letter-blind and had right homonymous hemianopsia. Her auditory memory was unaffected. Reëducation was started. After learning the alphabet she was allowed to spell out words letter by letter. In four months she had made considerable progress and could recognize any letter and many small words. Longer words she had to spell so as to get the aid of her ear. Two years later she could read as well as ever but the hemianopsia persisted.

Age evidently is a very important factor in the ability with which the patients are able to regain their lost powers. The cause in all these cases is cerebral hemorrhage. In such cases the process of reeducation should be delayed until all signs of acute brain symptoms have disappeared. In such cases it can be accomplished only by bringing into play the corresponding center on the other side of the brain. From these cases of acquired word-blindness and the experience of reëducation both in these and in congenital cases neither the old system nor that known as the ''look-and-say'' method is suitable for all cases. A great deal depends upon the degree of defect in the visual memory, and upon the condition of the auditory memory. When the visual memory is very defective and the auditory good, then the old system will give the best results; but when the auditory is not good the best results may be obtained by the ''look-and-say'' system. Lastly, personal teaching is necessary in all cases, and a number of short reading lessons during the day is better than one long one, for the brain rapidly becomes exhausted.

Chance (1913) has reported two cases, both of developmental word-blindness. Each patient had normal visual acuity. Although the first patient, a young man of 18 years, had attended school since his fifth or sixth year and was of good general intelligence, he could only read simple words with a good deal of effort. Yet he read off long rows of figures without the slightest hesitation, giving their significance as total sums even into the tens of billions. The second patient, a boy of 9 years, was equally deficient in spelling, but was an expert in mental arithmetic, although the sight of figures, as well as of letters, irritated him. Neither patient had any considerable refractive error.

More recently, T. R. Whipham (*Ophthalmoscope,* Jan., 1916) examined the records of about sixty-four cases of congenital word- and letter-blindness and considers that alexia congenita is more common than is usually supposed. It is more prevalent in boys than in girls, the ratio being forty-seven to seventeen. More than one member of a family may be affected. The writer records the history of one case in a healthy girl of 8, whose intelligence was moderately good, although perhaps a little below the normal standard. Her chief difficulty was with letters, both in reading and spelling. She had difficulty with words even of two letters. "At" would at times be written "ta," and "dog," "gdo." She could write her christian and surname together, but not separately. Writing from transcription, she made curious mistakes, *e. g.*, "transcriptino," "copy writino." She had no word-deafness. Her sight was good, and there was no hemianopsia or nystagmus. The Wassermann reaction was positive. The author expresses the opinion that the lesion may have been syphilitic, and situated around the posterior extremity of the fissure of Sylvius. The visual word and letter center is in the left supramarginal and angular convolutions. It is difficult to explain why the right side does not take on the functions. The outlook is not quite hopeless; improvement may be expected with systematic and sympathetic training.

In a case described by Gordon (*Oph. Year-Book,* p. 246, 1916) verbal amnesia and alexia developed individually after attacks of unconsciousness. Later on, paraphasia and paragraphia appeared. Not until two months after the first attack did a choked disk and retinal hemorrhages make themselves manifest. On operation, a glioma was found in the left lateral portions of the first and second temporal gyrus, angular gyrus, and occipital lobe.

R. Schröck (*Klin. Monatsbl. f. Augenheilk.*, Feb., 1915; abst. *Ophthalmoscope,* p. 203, Apr., 1916) says that the first complete accounts of word-blindness were given by British authors. Morgan had originally expressed the belief, confirmed by subsequent investigation, that the condition was the result of a development defect, and to Sydney Stephenson belongs the credit of having pointed out that it may show a familial incidence. The first case fully reported in German literature was that given by Peters in 1908.

The writer gives an account of five cases, three of which are in every respect typical.

Most cases of word-blindness, Schröck points out, come under the care of oculists, since their teachers or guardians, naturally enough, think that they are suffering from some ocular defect. It is an interesting fact that, even since the publication of Peters' case, very few cases have been reported in Germany, and a good many more in England. Schröck attributes this to the difficulty of learning to read the English language, owing to its non-phonetic spelling, rendering the discovery of the defect more certain. He nevertheless believes that the number of cases is no greater in one country than in the other.

With regard to etiology, Schröck believes that nothing has negatived the original suggestion of Morgan, that it is due to an aplasia of cerebral tissue in the region of the angular gyrus. Fisher saw three cases due to cerebral hemorrhage during birth, but the diagnosis was purely clinical, and not based on pathological findings. Although Ringer may, on theoretical grounds, be correct in stating that congenital word-blindness is a minimal form of idiocy, the author holds that it would be very wise to stigmatize these cases by the introduction of such a term. Several attempts have been made to find a more correct name than "word-blindness," but, whatever may be its drawbacks, this name has probably come to stay.

A comparison of all the published cases shows that they present a series of defects of varying intensity, from those in which apparently there is only a slight diminution of the nervous elements, the teachable class, to cases of absolute and irremediable defect. There is also an interesting group in which the defect is intermittent.

Weber (*Brit. Jour., Dis. Child.*, p. 176, 1918) describes a case—a boy of ten. There was the usual ability to recognize Arabic numerals, but an extreme backwardness in arithmetic. The patient had learned to write and to recognize his own name. There was no word-deafness and no aphasia. The eyes were normal and the patient was not color-blind. His mother had been somewhat backward in learning to read as a child. The patient's brother was not word- or letter-blind. The Wassermann reaction was positive in the mother and in the two children, and the father had died at the age of thirty-seven years in a lunatic asylum. Apart from the word-blindness the boy seemed intellectually almost normal. In another case described by Weber, the boy had apparently had a relatively mild attack of cerebrospinal meningitis or of acute encephalitis at the age of two years. The damage probably thus resulting to the cerebral cortical speech centers had resulted for a number of years in partial aphasia and dysarthria. Recovery finally occurred, this being attributed by Weber to a gradual process of compensation and reëducation.

Billström (*Svensk. Lak. Handl.*, p. 571, 1918; abst., *Oph. Lit.*, 1918) had an arteriosclerosis, who six weeks before coming into the hospital had had a short apoplectic seizure. The cerebral symptoms were a general psychic torpidity, complete verbal alexia, partial literal alexia, inability to form words out of letters, to read what he had written, and inability to copy what was written. The ability to write spontaneously from dictation was retained. Death occurred a month later. Post-mortem examination showed softening of the angular gyrus of the left side of the brain.

Several cases of developmental alexia or congenital word-blindness are related by Heitmuller. Two of the patients had letter- and word-blindness, while the other two knew the alphabet but could not read or spell words of more than one syllable.

Schröck (*Klin. Monatsbl. f. Augenheilk.*, March, 1915) correctly assigns the description of the first cases to James Kerr (Howard Prize Essay of the Royal Statistical Society, June, 1896, and *Lancet*, May 19, 1900, p. 1,446), and alludes to other cases by Morgan (1896), Hinshelwood, Nettleship, Wernicke (1903), Lechner (1903), Stephenson (1904), Bruner (1905), Thomas (1905), Schapringer, Claiborne (1906), Variot and Lecompte (1906), Fisher (1915), and others. Until 1908 in Germany the condition had not received the attention it deserved. Peters then drew attention to congenital word-blindness.

Word-dumbness. VISUAL ANOMIA. In this condition the patient is unable to name by sight an object with which he is familiar. The object is given a wrong name. If the eyes are closed, the object may be recognized by touch or by other senses. It has been caused by lesions situated in various parts of the zone of speech. See **Visual aphasia,** and **Visual anomia.**

Wordsworth, John Cawood. A well-known English military surgeon and ophthalmologist. Born in 1823, he studied at first with John Jesse in Manchester, then at the London Hospital. Because of failing health he removed to St. Kitts, British West Indies, where he practised for three years. Returning to London, he was appointed in 1849 demonstrator of anatomy and assistant surgeon at the London Hospital, and in 1852 surgeon at Moorfields. In 1852 he entered the English army as volunteer physician, and served at Smyrna and Sebastopol. Returning to London, he began in 1859 to devote himself exclusively to ophthalmology, and for 31 years was engaged in active work at Moorfields. In 1870 his health began to fail again, and in 1883 he resigned his Moorfields position. Three years later he died.

Wordsworth wrote no book, but a number of articles which chiefly appear in the *Ophthalmic Hospital Reports.* He also wrote "On the Value of the Ophthalmoscope" (*Med. Times and Gazette,* Apr. 9, 1859).—(T. H. S.)

Worker ants. Worker or laborer ants, being "cave-dwellers," have either no eyes or mere vestiges of these organs. See **Ants, Vision of,** in the *Appendix* to this *Encyclopedia.*

Working distance. (1) The distance (generally one-third of a meter) from the eyes at which an individual ordinarily uses his eyes—at his usual occupation. (2) A term used specially with reference to microscope objectives, to denote the distance between the front focal or object plane and the first lens surface.

Workman's compensation for damaged eyesight. See **Legal relations of ophthalmology,** in the last third of the section; also, **Visual economics.**

Workshops for the blind. See **Blind, Institutions for the.**

Worm-like movements of the pupil. See end of section on **Pupil in health and disease.**

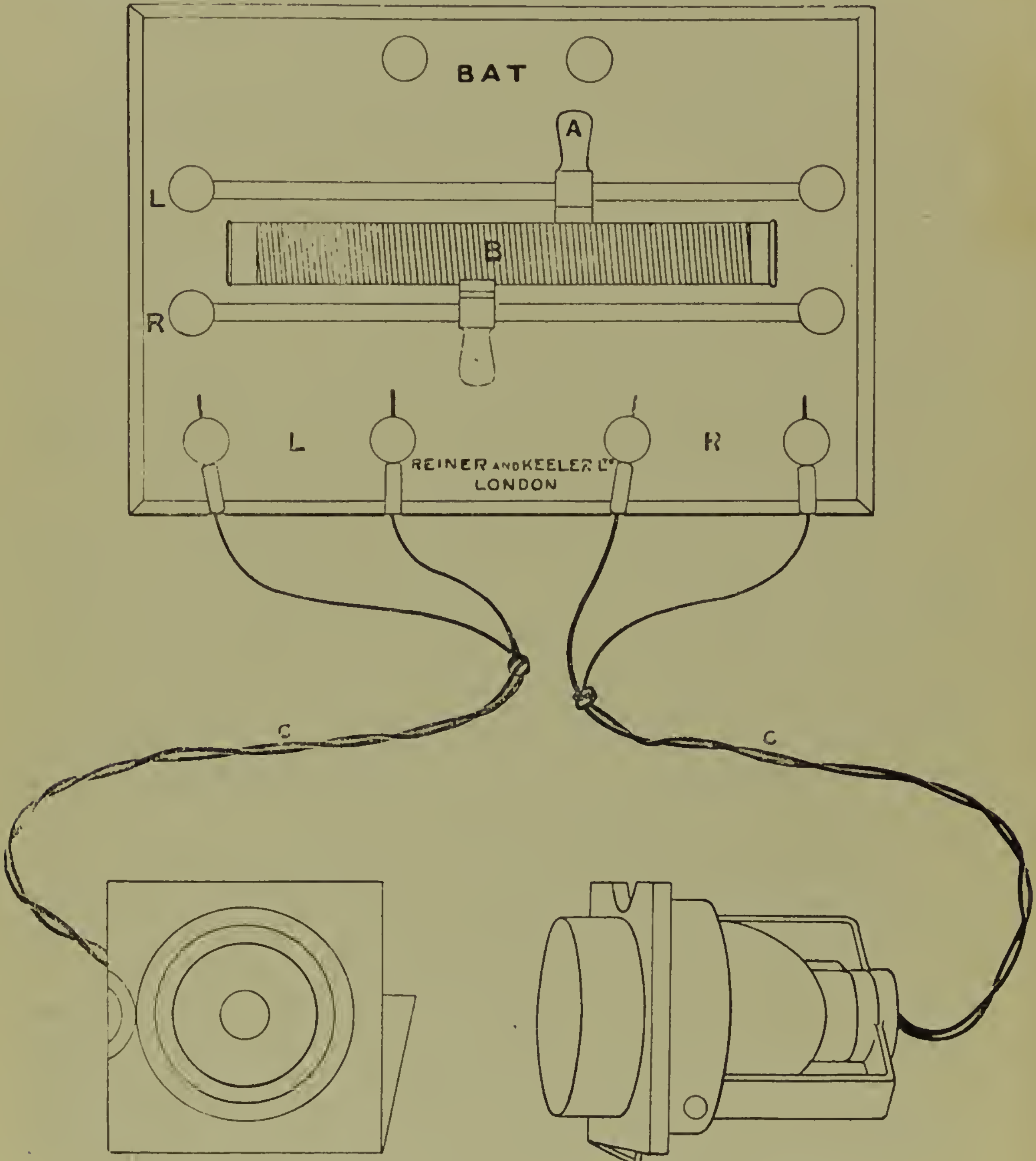
Worms, Eyes of. See p. 2538, Vol. IV of this *Encyclopedia.*

Worsted test. See Holmgren yarn test for color-blindness, p. 2448. Vol. IV of this *Encyclopedia.*

Worth's amblyoscope. See p. 306, Vol. I, as well as under **Strabismus**; **Muscles, Ocular**; and the various **Fusion** and **Stereoscope** headings in this *Encyclopedia.*

Recently, an electrical attachment, suggested by H. H. Cunningham, has been fitted to the standard Worth amblyoscope. It permits either of the two lamps used to illuminate the pictures to be individually dimmed or brightened without affecting the other. This convenience is of considerably more value to the surgeon than a system whereby as one lamp is brightened the other automatically becomes dim, as it enables him to give the instrument to a patient and always have the pictures brilliantly and evenly illuminated, no matter what conditions of light or shade prevail at the time. The switchboard is of simple design, consisting only of a rheostat with two sliding contacts working one on each side, and three pairs of terminals—one pair for battery, and the remaining pair for the lamps. The electrical fittings are detachable and are fitted to the amblyoscope by sliding them on in place of the ordinary picture carriers.

The electrical fittings have a picture carrier with spring release incorporated with them, so that the amblyoscope can be used either with or without electrical illumination at will. The standard lamps supplied are 4 volt, but other voltages may be fitted to order. See the illustration.



Electrical Attachment for the Worth Amblyoscope. (Cunningham.)

Wounds of the eye. See **Injuries of the eye**; as well as **Military surgery of the eye**; **War, Ophthalmic medicine and surgery in**; and other injuries of ocular organs and parts.

Wright, Halstead Robert. A young American ophthalmologist of great promise. Born at Coshocton, Ohio, May 20, 1875, he removed to Columbus with his father's family in 1880. He graduated in dentistry at the University of Ohio in 1895, but after a brief period of dental practice, took up the study of medicine in the same university, where he received the medical degree in 1910.

He then located for practice in Columbus, becoming a partner with his father. He was, from 1910 till 1917, instructor in physiology and pathology at his alma mater. He invented a number of ophthalmic instruments, and contributed to "*The Ophthalmic Record*" a number of ophthalmologic articles, among which may be mentioned the following: "The use of the Snare as the final Step in the Enucleation of the Eye"; "A New Method of Preparing an Eye for Microscopic Sections"; "A Rare Intraocular Tumor" and "A Rare Tubercular Condition of the Eye."

Wright was a large, robust man, smooth faced, of fair complexion, with dark-brown eyes and hair. He was very serious in manner as a rule, but enjoyed an occasional joke. He was very fond of fishing. He became a captain in the Medical Service of the Army, and died at Camp Greenleaf, Georgia, Oct. 17, 1918, survived by his father, also by his wife and son.—(T. H. S.)

Writing, Mirror. See **Mirror writing**, p. 7843, Vol. X of this *Encyclopedia.*

Perhaps the latest exposition of this much debated subject is given in the *Literary Digest,* Aug. 16, 1919, as an abstract of Arthur L. Beeley's *Left-Handedness,* 1919. The writer refers to the blotting-paper character of the script and says that many persons, when they try to write with the left hand, find it most natural to produce script of this kind, and left-handed persons often show a tendency to write in this way. Many authorities believe that this tendency has some relation to mental deficiency, and it hence becomes interesting to psychologists as well as to investigators of "handedness"—the customary use of either the right or left hand. Beeley quotes first from J. Mark Baldwin's *Mental Development and the Child,* as follows: Mirror-writing is the form of inscription which arises from tracing words with the left hand by an exact reduplication of the movements of the right hand, in a symmetrical way from the central point in front of the body, out toward the left. It produces a form of reversed writing which can not be read until it is seen in a mirror. Many left-handed children tend to write in this way. Some adults, on taking a pen to write with the left hand, find they can write only in this way. Even those, like myself, to whom the movements seem, when thought of in visual terms, quite confusing and impossible, yet find when they try to write with both hands together, in the air, from a central point right and left, that the left-hand mirror-writing movements are very natural and easy.

Beeley says that Judd, in discussing the subject holds that "mirror-writing" frequently characterizes abnormal individuals. Not alone do certain children exhibit this tendency in the early years of their training, but, he maintains, some persons when hypnotized execute "mirror-writing" with the right hand.

Few writers in the field of normal and abnormal psychology discuss the characteristic in question, but of those who do most of them believe "mirror-writing" to be positively correlated with mental deficiency. One authority on mental deficiency, Barr, holds that it exists among learned idiots, *i. e.*, mental defectives with special talents in various directions but otherwise deficient mentally and physically. He further adds: "Many of those exhibited in cheap museums or the side-shows of the circus as 'lightning calculators,' 'musical phenomena,' 'mirror-writers,' and as wonderful checker-, card-, or chess-players' belong to this class."

The contribution of Sherlock is well worth quoting. He says:

There is one manifestation of abnormal tendency in the employment of language which has acquired, in the popular conception of idiocy, a prominence attributable to its curious character rather than to its value as a guide to the mental state. This is what is called "mirror-writing." . . . Good examples of this kind of writing are rare, at any rate in this country (England), for idiots either do not write at all or they produce a scrawl which demands the use of a good deal of ingenuity in addition to a mirror if anything is to be made of it. Mirror-writing occurs in idiots who are capable of a limited degree of calligraphic attainment, but incapable of learning to write properly.

In one hundred and three Chicago schools responding to a questionnaire sent out by Mr. Beeley on this subject, forty-two cases of tendency to mirror-writing were found. In most of these the tendency had been wholly overcome, but in others only partly. They were all left-handed. Only nine were reported as mentally deficient or troubled with nervousness or defects of speech. Beeley concludes that "mirror-writing" has primarily nothing to do with idiocy, but is simply the easiest method of producing script with the left hand, as the ordinary form is with the right. This is also the opinion of Baldwin. When any motions are made with both hands at once, they tend to be symmetrical, which means "mirror-writing" with the left hand when the motions of ordinary script are made with the right. It is easy for any one to try the experiment.

Wundstaar. (G.) Traumatic cataract.

Wurde, Nicasius de. A famous blind priest. See **Werde, Nicaise de.**

Wurstvergiftung. (G.) A morbid condition produced by eating unwholesome sausages, in which the vision is often affected.

Wutzer, Karl Wilhelm. A distinguished German surgeon and ophthalmologist, especially renowned for his operative skill. Born at Berlin, Mar. 17, 1789, the son of a surgeon and inspector of baths, he studied for a time at the medico-chirurgical Pépiniere at Berlin, and then became a military surgeon. Having reached the rank of regimental surgeon, he resigned his military work, and, receiving his degree in 1817, traveled for a time in Germany, France and Italy. At length (in 1821) he began to write books and articles which soon were to make him famous.

After the death of Weinhold, in 1830, he removed to Halle, in order to accept the chair of surgery in the Hallean University, and the directorship of the Hallean Surgical Hospital. In 1833, he removed again, this time to Bonn, where he was made successor to Philip Franz von Walther, in the chair of ophthalmology. During his residence at Bonn it was that he wrote the most of his ophthalmic books and articles.

In Berlin, in 1858, Wutzer was operated on for double-sided cataract, but, by the irony of fate, received (as has so often happened in the case of distinguished ophthalmologists) merely a modicum of vision. Indeed, in one eye sight did not return at all. His operative activities, of course, were, from this time forward, effectually put an end to. Wutzer, however, continued to write, and some of the best of his articles were produced in the period of his lowered vision. He died suddenly on Sept. 19, 1863.

The universal testimony of friends and enemies alike was that Wutzer was a man of most extraordinary ability both as surgeon and ophthalmologist. According to Gurlt and to Weber he was also a man of very friendly character, of the utmost honesty, and of infinite energy and patience.

In addition to numerous original and excellent articles on the eye, he made a good translation into German of van Onsenoort's "*Geschichte der Augenheilkunde*" (Bonn, 1838), a work of value in its day, but long since superceded.—(T. H. S.)

Wy, Gerrit Jan van. An 18th century Dutch anatomist, surgeon, obstetrician and ophthalmologist of little importance. He wrote "*Over de Nuttigheid, Noodzakelykheid, Voortreffelykhaid en Luister der Genees- en Heelkunst*" (Arnhem, 1788), and "*Nieuwe Manier van Cataract of Staarsnyding Benoffens Heel en Vrädkundige Waarnemingen*" (Arnhem, 1792).—(T. H. S.)

Wyler, Jesse Sydney. A well-known ophthalmologist of Cincinnati, O., who died young, but who had given much promise of great things. He was born at Cincinnati, Sept. 7, 1879, son of Isaac A. and Adelaide (Lowman) Wyler. His medical degree was received at Miami Medical College in 1904. After serving as interne in the old City Hospital, he continued his studies in Europe. Returning to Cincinnati, he soon was widely known as a skillful operator. He was elected to the staff of the Cincinnati General Hospital in 1910 and to the staff of the Jewish Hospital in 1912.

Dr. Wyler was a stout man, of medium height, smooth-faced, of a ruddy complexion and with bright brown eyes and hair. He was gay and genial, very fond of children, a collector of books, a Republican, not a religionist but a Jew by birth. He married, Nov. 30, 1908, Miss Florence Iglauer, by whom he had two children. He died at Cincinnati, Oct. 28, 1918.

Concerning the personality of this very able man, we are glad to quote the following from Dr. Derrick T. Vail, who knew him intimately: "Dr. Wyler was one of those enthusiastic, active, able and gifted men who studied ophthalmology not of necessity, for he came from a family possessing ample means, but because he was ambitious and had a natural desire for a scientific and professional career. He did not, therefore, declare himself an ophthalmologist and begin practising before he was properly equipped.

"He possessed a fine education, spoke the German and French languages fluently, also had a reading knowledge of Spanish and Italian. He was actively connected with the *American Journal of Ophthalmology* on the staff of collaborators. Dr. Wyler enjoyed the high esteem of a wide circle of friends both in the profession and out of it. His mind was overflowing with information for he was a keen observer, a good student and had strong convictions for or against the many ophthalmological problems. He was fond of an argument and always believed he was right but was never obnoxious in his manner. He was a very skillful operator. His methods were largely of the Viennese school.

"His pre-war admiration for the Vienna and Berlin schools of ophthalmology was very great. After our country became involved in the war, however, Dr. Wyler's patriotism and loyalty to our country were very keen and genuine. President Dabney of the University of Cincinnati testified that he died in the service of our country.

"He was very kind and liberal to the poor and would give them his best time and services without stint. He was just rounding into the climax of a great career when stricken with pneumonia following influenza.''—(T. H. S.)

X

Xanthelasma. Xanthoma. Vitiligoidea. This is a tumor-like growth —the *plain varicy* of which is a smooth, flat, yellowish deposit generally in the palpebral skin due to alterations in the superficial muscle fibres. It occurs as an irregular, round or oval patch, or patches, near the inner canthus and commonly affects the upper lids of elderly females. It is a benign growth which rarely calls for interference except for cosmetic reasons, when the following may be used: Hydrarg. bichlor., ʒi; Collodion, ʒiii. Apply with a camel's hair brush.

An eschar forms in a few days, which finally falls off, leaving a faint scar. The X-rays also constitute an effective remedy.

S. B. Muncaster advises the use of monochloracetic acid for the removal of this disease. A solution of one part to two of water is applied by means of a piece of cotton on the end of a tooth-pick. A few seconds after the application the yellow discoloration becomes white. On the second day there is swelling; in about a week or ten days a scab forms and falls off, leaving a clean surface without any scar. In some cases it is necessary to make a second or, perhaps, a third application at intervals of four to six weeks.

See **Eyelids, Xanthoma of the,** p. 5030, Vol. VII of this *Encyclopedia.*

Xanthelasma of the ocular conjunctiva is occasionally seen as slightly raised, irregular, yellowish plaques. These are found in the interpalpebral space near the limbus.

Xanthelasma of the cornea. This rare degeneration is characterized by its yellow color. It follows injuries attended with shrinking of the globe and often exists with a calcareous deposit in the cornea. Such eyes are usually sightless. They are prone to occasional attacks of inflammation and may be the cause of sympathetic ophthalmitis. There is no particular treatment for the condition. If indicated, an enucleation or a Mules operation should be performed.—(J. M. B.)

Regarding the pathology of xanthelasma Parsons notes that it occurs most frequently in jaundice.

Hutchinson (*Oph. Year-Book*, p. 285, 1909) shows that the patches result from deposit of a fatty acid from the bile, in the sebaceous, and rarely also in sudoriparous glands. They usually occur in "bilious" individuals subject to symptoms attributed to the liver, sick-headache, etc. Gilbert and Lereboullet also insist upon the connection of xanthelasma with hepatic affections. They report two cases showing that the former may persist after the cause has been removed. Ring's case showed extensive splotches, 11 by 6 mm. in size, of xanthelasma in a woman on each upper and lower eyelid, at the inner angle of each lower lid. A small spot was present at the outer canthus of each eye. Diabetes, tuberculosis and syphilis could be excluded.

Pincus and Pick deny any distinction between diabetic and other forms of xanthoma. They have found in the xanthomatous cells the substance which has thus far been considered as fat to be in reality a body resulting from the combination of a fatty acid with cholesterin. This finding furnishes an explanation for the predilection, heretofore enigmatic, of xanthoma for icterns and diabetes; in both of which conditions the same combination is known to occur in the blood.

On the other hand, J. Mawas (*Ann. d'Oculistique,* June, 1914), after a study of the histology of xanthelasma palpebrarum, and after a careful investigation of the nature of the xanthelasma cell in a series of specimens obtained from 20 patients, finds that the xanthelasma plaques are very variable in form and appearance, but most frequently occur as small tumors composed of a series of lobules, separated from each other by more or less thick connective tissue septa, and containing, when suitably treated, typical cellular elements. These contain lipoid elements, which are more or less soluble according to the stage of development which they have reached. These appear first as tiny granules, the number and size of which continually increase until they finally coalesce and fill the cell. The cells also have a tendency to coalesce, giving rise to polynuclear xanthelasmic cells resembling giant cells. The writer considers that these cells are of a glandular type, elaborating in their protoplasm a peculiar lipoid product. He rejects the theories that the cells are undergoing fatty degeneration or are phagocytic.

As a contribution to the treatment of xanthelasma, two cases of flat xanthoma, localized on the lids, are described by O. Schindler (*Prac. Med. Series,* p. 31, 1912), in which he obtained splendid cosmetic results by exposure to 25 mgr. radium bromid. Under the same treatment over 20 cases of rodent ulcer, lupus and angiomatous nevi, healed without subsequent atrophy of the skin or telangiectasiæ, occasionally observed after radiation by Röntgen rays or radium. According to Jarisch, excision is the only treatment which insures a radical effect, and Schindler found no observations on radium therapy in the literature. He considers as chief indications for treatment with radium very extensive affections, in which one does not wish to sacrifice too much of the skin of the lid, and the frequent relapses in the surroundings of the operation scars. It is preferable to the treatment with Röntgen rays on account of the more exact limitation and mode of application and the better protection of the eye against unpleasant complications.

Xanthocyanopsia. Xanthocyanopsy. Ability to discern yellow and blue tints, but not red or green.

Xanthoma. See **Xanthelasma.**

Xanthometry. A term invented by Hess to describe the measurement of the amount of yellow in the crystalline lens. See **Coloration of the human lens,** p. 2363, Vol. IV of this *Encyclopedia.*

Xanthophane. See **Chromophane,** p. 2206, Vol. III of this *Encyclopedia.*

Xanthophose. Any yellow or yellowish phose.

Xanthophthalmous. Yellow-eyed; used not only of persons with yellow irides, but also of those with yellowish conjunctival discolorations due to jaundice and the like.

Xanthopia. Same as xanthopsia.

Xanthopsia. Yellow vision. A condition in which objects looked at appear yellow. See **Chromatopsias,** pp. 2198 and 2202, Vol. IV; also under **Santonin,** of this *Encyclopedia.*

This anomaly has occurred as an accompanying symptom in cases of intestinal parasites; from the effects of intense electric light; in a fatal case of Weil's disease; in influenza; and in various nervous disturbances. One case developed after a preliminary iridectomy, and one case accompanied the occurrence of nephritis of pregnancy, in which there was seen ophthalmoscopically a slight edema of the papilla.

H. Yamaguchi has reported (*Oph. Lit.,* Aug. 1913) the case of a man of 38 years who had often had xanthopsia lasting almost a day. He took a powder (of a mixture called semengan, containing 0.1 gm. of santonin) morning and evening. Feeling no better that evening he was given santonin by a physician, and passed worms. The next day he had yellow vision, of which he took no notice and which soon disappeared from the left eye. The persistence in the right eye was particularly marked in the middle of the field. Twenty-five days later the vision of the right eye with correcting lens was 0.5, there was slight clouding of the vitreous, the macular retina was hyperemic, and vision was cloudy. There was no notable change in the left eye. He was treated with potassium iodide, cathartics and sudorifics, and put to rest. The xanthopia finally disappeared after lasting the extraordinary period of thirty-seven days. The maximum dose of santonin is 0.1 gm., or 0.3 gm. per diem. The patient had taken on the first day only 0.1 gm. and in the next four days at most 0.4 gm.

The round worm is widely distributed in Japan, and when its presence is suspected it is the custom to take this preparation of semengan.—(C. P. S.)

R. Hilbert (*Klin. Mon. f. Aug.*, 51, I, p. 494, Apr., 1913) supplements his essay on the pathology of the color-sense and reports a case of xanthopsia in a young, very neurasthenic, man, who after an alcoholic excess complained for three hours of seeing yellow.

Xanthopsin. Visual purple, partially discolored or bleached by light; visual yellow. See **Bleaching of the visual purple,** p. 1015, Vol. II of this *Encyclopedia*.

Xenogenous siderosis. See **Siderosis of the eye.**

Xenophthalmia. Traumatic conjunctivitis.

Xerocollyrium. A dry collyrium; an eye-salve.

Xeroderma. This is a disease marked by roughness, scaliness and dryness of the skin, resembling somewhat ichthyosis. See **Conjunctivitis entomotoxica.** A few cases of xeroderma of the eyelids are on record.

Xeroderma pigmentosum. Kaposi's disease. Lentigo maligna. In addition to the matter on p. 6740, Vol. IX of this *Encyclopedia,* it may be said here that epithelioma and papilloma are associated, often, with the carcinomatous degeneration of xeroderma pigmentosum. Pergens (1909) met with four instances of xeroderma pigmentosum, *three involving the conjunctiva,* in members of one family with distant consanguinity of the parents.

Uhthoff (1913) has described the changes wrought by xeroderma pigmentosum in the lower lids and corneas of a 14-year-old girl whose case was reported by Heine seven years before. The vision had been lost as the result of adhesions between the lids and cornea, the lower half of the conjunctival sac being completely obliterated by contraction. There were xerodermal tumors in other parts of the body.

Sulzer (*Ann. d'Oculistique*, July, 1913) describes two cases showing conjunctival vascularization of the shape of pterygium with pigmented spots at the limbus resembling phlyctens, circumscribed, pearl-shaped corneal infiltrations, and diffuse corneal infiltration. The presence of small, round pigmented cells in circumscribed corneal infiltrations showed them to be xerodermic lesions, but the writer regards the diffuse corneal infiltration as an unimportant secondary lesion, due to loss of protection owing to deformity of the eyelids.

The relations between freckles (*lentigo:* see **Eyelids, Freckles of the,** p. 5007, Vol. VII of this *Encyclopedia*) and xeroderma pigmentosum are thoroughly discussed by Richardson Cross (*Ophthalm. Review,* p. 193, July, 1915) who also gives a complete account of the ocular manifestations of the latter. He points out that ordinary lentigo is an affection of frequent occurrence and great variation, and is due to localized increases or accumulations of the pigment cells in the rete mucosum. The spots usually occur almost entirely on the face and arms, and on parts of the body surface which have been exposed to the sun (ephelis). They first appear on the approach of summer, and as the cold weather supervenes they tend to pass away.

Though the spots may begin to show at any time of life, they are seldom seen before the fourth year; they are much more common in childhood, though they may be present in later life. The spots are unsightly, but they rarely cause other trouble or lead to any further complications.

Spots like freckles which appear in the first year or two of life are often the precursors of the grave and rare form of skin disease which was described by Kaposi in 1870, and which goes by his name. The pigment spots are then accompanied by dryness and atrophy of the skin, and by other more serious changes in it. The condition has been well called *lentigo maligna.*

The freckles usually appear very early in life, and occasionally only a few months after birth. Two or more brothers or sisters (usually the same sex) are frequently affected. The disease probably depends on a congenital predisposition to a faulty innervation which tends to irregular nutrition of the skin or to abnormal changes and formations in the vascular and pigmentary portions of its papillary layer.

Well defined dark or lighter pigmented spots appear on the uncovered, exposed portions of the head, shoulders and limbs; in addition the skin begins to shrink, showing white atrophied areas of contractions and thinning, hence the name preferred by Radcliffe Crocker, atrophoderma pigmentosum. The skin is very dry and rough in the affected parts; it feels thin and tense and stretched, resembling parchment. Kaposi prefers the name xeroderma pigmentosum, which he originally gave it, and by which the disease is usually known.

With time other forms of deterioration show themselves in the epidermis and papillary layers. Fine capillary and vascular telcangiectases develop.

Some of the pigment spots coalesce and form moles. Warts and papules grow: some on fine pedicles so that they easily fall off, others with broad bases which may ulcerate and discharge with scabbed sores or may increase in size and form tumors which take on malignant changes.

The new growths show various types of tumor tissue: granuloma, epithelioma, sarcoma, myxoma, angioma; and in a growth from a case of Crocker's examined by Politzer all these types were seen combined together.

The disease is confined to the integument, the tumors do not penetrate below the corium, and there seems to be no tendency to implication of the lymphatics, or to metastases of the internal organs.

The prognosis is hopeless. No definite improvement has been seen in any of the hundred or so cases which have been reported, but constant attention and treatment of the local manifestations as they arise seems to keep the disease in abeyance. Some patients live for many years, but, on the other hand, early death may occur from deep ulceration toward the brain or other vital parts, or from exhaustion or hemorrhage.

The most marked changes are seen in the face. The mucocutaneous surfaces at the mouth and eyelids become thinned and shrinking or fissured with superficial ulcers, and the lips become white and mottled with red, vascular spots; any of the pathological changes earlier mentioned may occur. The ears and nose edges seem particularly liable to growths and ulceration, and, as the lids and surface of the eyeball are continuous with the skin of the face, they may also participate in any phase of the disease.

The pigmentation and thinning of the eyelids is associated with a dry and rough conjunctival surface and with shrunken eye-lashes. On the lid edges warts may occur, or inflamed papules like styes, which tend to ulcerate. Nodular swellings may grow on the skin surface of the eyelids and towards the caruncle. The ocular conjunctiva is usually hyperemic, from a general congestive fullness of the vessels, or with acutely inflamed patches which often run to the edge of the cornea.

Some cases are said to have shown pterygium, but the nodules are probably more frequently allied to phlycten or pinguecula. The edge of the cornea seems particularly prone to implication—a patch of hyperemia simply, or complicated with swelling and deposition of cells which may absorb again, or may form corneal ulcers, or else lead on to the formation of a neoplasm. The cornea itself becomes hazy from infiltration of its substance, or from swelling of the epithelium. In these cases there is photophobia and blepharospasm. Ectropion is frequently present, and leads to opacity or ulcer of the cornea; but in many of the cases that have been depicted—Crocker's and others—the eyes are open and the light seems to be well born.

The optic nerve and the intra-ocular structures are probably not affected excepting as a late complication of more superficial lesions, and even iritis is probably seldom present unless the cornea has first become very deeply affected.

Although the cases cannot be cured, persistent treatment gives much relief. The discharge from the irritable conjunctiva or from ulcers must be constantly washed away by soothing, antiseptic solutions so as to avoid irritation and eczema of the neighboring skin.

The growths need to be repeatedly removed and eradicated and the ulcers scraped. The application of massage to the eyeball empties the superficial blood-vessels and the swelling of the cornea. Cross has applied a calomel ointment with good results and used it as a medium for massage. Cocain is comforting, but damages the corneal epithelium; atropin appears to aggravate the photophobia, and as iritis is probably not an early symptom, and rarely present until the eye is very seriously damaged, is not usually needed.

Colored veils and ointments may protect the skin.

One of the writer's patients was much improved by the application of X-rays.

In a case of xeroderma pigmentosum, with post-mortem examination, reported by T. McCall Anderson (*Brit. Med. Journ.*, June 8, 1889), a boy, aged 9, affected with the disease, showed freckles, abnormal vascular areas, and a few rounded nodules scattered over the face: the largest of these was situated on the inner side of the left eyeball and was removed. It soon reappeared, extended rapidly in the orbit, and destroyed the sight; finally the eye had to be enucleated. There was no return of the disease or further material change in his condition for four years, when the disease again became active on the other side of the face. Rapid malignant ulcerations destroyed the skin on the right side of the face, with the bones and cavities underlying, so that at the end of a year the boy died when only 13 years of age.

The post-mortem examination showed that the right side of the face was eaten away into the nose and pharynx and into the anterior and middle fossæ of the skull, but there was no affection of the glands or of the internal organs.

Brayton records two cases, a brother and sister, each of whom were attacked between the fifth and sixth months of life. The boy died of a malignant disease of the face with ulceration at 9 years old.

The girl, although showing the typical signs of the disease, continued to be well developed, and otherwise in good health when last seen at the age of 15 years.

Cross describes two of his own cases of Kaposi's disease—a brother, aged 11, and a sister, eighteen months younger. They were the children of healthy parents—cousins.

The boy was born in Ceylon, and when nine months old, he became very sunburnt (erythema solare). His skin became scarlet, like a lobster, and a little later the face, neck, shoulders and arms became dotted over with pigmented spots of a brown or yellowish color; the skin also became thin and shrunken, and other symptoms of the disease followed. The girl was born in England and went back to Ceylon as a baby. Her journey was made when there was no special sun glare. She reached Ceylon at four months old, and until nine months old she was quite well. Then freckles began to appear on the exposed parts of her body, face, hands, neck, and a little on the legs. The skin looked dry and parched, and her general health became bad. At a year and a half old a small nodular growth appeared on the chest, but fell off leaving no scar nor ulcer.

The boy had the first growth when between two and three years old. Both children continued to be affected, and similar pendulous growths fell off. The girl in this respect appears to have been the worse of the two. She had many flat, papular swellings in various parts, the nose, cheek and forehead. The edge of the eyelids was also implicated, producing eversion. The boy also had many papular swellings, but the tendency of them was less well marked, and they usually fell away. He became practically free of them but was much pigmented; while in the sister some have been very troublesome, remaining fleshy, and not tending to dry up. Some of these have been treated with x-rays, which have also healed up some ulcers on the nose.

N. C. Nelson (*Am. Journ. Ophthalm.*, p. 445, June, 1919) reported a case with thickened condition of the lower lid, and ectropion. To 1870 there had not been many of these cases reported, but between that time and 1910 there had been something less than 100 cases recorded in the medical literature of the United States alone.

Xeroform. Bismuth tribromocarbolate. Bismuth tribromophenate. This remedy is a yellow, insoluble powder, neutral, odorless and tasteless; containing about 60 per cent. of dibismuth trioxide.

The editor has found it a valuable substitute for iodoform, especially in wounds of the lid and as a dressing after orbital operations, where the former agent is especially offensive, as, indeed, it usually is, especially to the patient operated on. He has also employed it, with satisfaction, as a dusting powder, or applied with an insufflator, in corneal ulcer.

In phlyctenular keratitis Ray H. Dean uses it as a dusting powder not only to the cornea and conjunctiva but on the skin surface of the lids. He also employs it where iodoform powder is usually required. In the form of dry xeroform gauze applied to the eye with a bandage he finds it of great value as an antiseptic dressing.

Xeroma. An abnormally dry condition of the conjunctiva; xerophthalmia. See **Xerophthalmia.**

Xerophthalmia. XEROPHTHALMOS. XEROPHTHALMUS. XEROSIS EPITHELIALIS. XEROSIS CONJUNCTIVÆ. ATROPHY OF THE CONJUNCTIVA. In this condition the conjunctiva becomes thick, dry, and of a whitish color resembling skin. An analogous process is observed in the cornea. Xerosis of the conjunctiva appears either sequent to a local disease or as an accompaniment of a general affection. Locally it occurs after cicatricial degeneration following trachoma, pemphigus, burns, or diphtheritic conjunctivitis (parenchymatous xerosis); or it may be due to insufficient protection, as in ectropion and lagophthalmos, the exposed conjunctiva becoming covered with a thick, epidermoid epithelium (epithelial xerosis). Resulting from a general disease, conjunctival xerosis occurs in a light and also in a severe type. The former accompanies nyctalopia, while the latter is found in cases of keratomalacia. A special bacillus (*xerosis bacillus*) has been described. According to Fuchs, it is neither the cause of xerosis nor characteristic of this disease, since it is found in the healthy conjunctival sac.

In the primary type the part of the conjunctiva corresponding to the palpebral opening shows a froth-like deposit (composed of degenerated epithelium), which is triangular in form, the base being toward the cornea. The conjunctiva is anesthetic and irritation fails to produce lachrymation. In severe cases the cornea becomes dull and opaque and may slough. An important subjective symptom is night-blindness. The disease is common in Brazil and among the negroes of the South. Prognosis is unfavorable.

Primary xerosis of the conjunctiva is found chiefly among the ill-nourished and calls for supportive and tonic treatment. Local treatment is of little value. Glycerin and water, an emulsion of codliver-oil, or white vaselin may be used as local applications with comfort to the patient.

See, also, **Pemphigus**; also **Bacillus xerosis,** pp. 747 and 780, Vol. II of this *Encyclopedia.*

As Parsons (*Pathology of the Eye,* p. 102) points out, xerosis of the conjunctiva is not a distinct disease but a symptom. He gives the following excellent account (which is given verbatim) of this condition:—Xerosis of the conjunctiva occurs in two groups of cases: (1) associated with general disease; (2) as a sequel of local ocular affection.

The *first type* occurs in two forms: (a) a mild form, found in adults, accompanied by nyctalopia, and characterized by Bitot's spots, small triangular patches on the outer and inner sides, covered by a material resembling dried foam, which is not wetted by the tears; (b) a severe form, found in marasmic children, associated with keratomalacia and necrosis of the cornea. Both these forms probably result from malnutrition.

The *second type* occurs as a cicatricial degeneration of the conjunctiva—(a) following trachoma, burns, pemphigus, diphtheria, etc., commencing in isolated spots, ultimately involving the whole conjunctiva and cornea; (b) following exposure, due to ectropion or lagophthalmos.

In all cases the principal anatomical changes are found in the epithelium, which becomes thickened and epidermoid, at the same time undergoing fatty degeneration. Leber first described sections through the whole thickness of the membrane. The superficial cells are flattened, and their nuclei have disappeared; the deeper layers consist of prickle-cells, often widely separated by spaces in which leucocytes are found. The nuclei of these cells stain well, and are surrounded by a clear zone, outside which there are numerous fat globules; these, however, are much more numerous in the flattened cells. Much of the fat is due to the secretion of the Meibomian glands, which is increased. If the fat is removed by soap the cells become capable of being wetted by the tears.

The surface of the epithelium is for the most part even; but here and there the deeper cells are irregularly clumped together and separated from their neighbors, and these balls of epithelium often project above the surface, and later become free in the conjunctival sac (Kuschbert). They contain numerous intra- and extra-cellular "xerosis" bacilli, which grow rapidly under the conditions which exist, but are not the cause of the complaint.

Baas found few leucocytes between the deeper cells. Changes in the protoplasm and nuclei commenced in the middle layers. The protoplasm showed uneven staining—either a clear or a deeply-stained zone around the nucleus, or general faint staining; there were also vacuoles. The nuclei stained less than normal, especially at the periphery; in other cells the centre was less stained, so that the nuclei assumed the signet-ring form. The fat globules stained deeply with osmic acid, so that the superficial cells often became filled with reduced osmium.

Attention has more recently been devoted to the horny changes which take place in the more superficial cells (Dötsch, Basso). Those slightly below the surface show granules in the cytoplasm which stain very deeply with hematoxylin. The granules consist of keratohyalin, and the layer in every respect resembles the stratum granulosum of the epidermis. The horny cells upon the surface stain very deeply in a diffuse manner, showing no granules. The cells here are often united into long wavy bands or lamellæ (Basso).

This epidermoid condition of the conjunctiva has been called tyloma conjunctivæ by Gallenga and Best. It probably occurs in rare cases as a congenital malformation—the simplest type of dermoid.

Keratohyalin, besides staining deeply with hematoxylin, also stains by Gram's method, differing from other substances in retaining the stain when treated with acid alcohol (Ernst). It also stains with Weigert's fibrin stain, and becomes deep blue with iron hematoxylin (Apolant). The strong affinity for hematoxylin is shown by Unna's method, in which overstained sections are differentiated with potassium permanganate solution. Keratohyalin shows the red fuchsin stain with van Gieson's method, whereas the more advanced horny material in the superficial cells stains yellow.

Xerosis epithelialis. In this particular form of xerophthalmia the cornea may or may not be involved. The condition is known, also, as *xerosis triangularis* and *xerosis infantilis* and by some writers (Weeks, for instance) is confined to that form of xerophthalmus in which the lesions are believed to be due to the diplobacillus of xerosis. Others regard epithelial xerosis as a state of the conjunctiva which from exposure (ectropion, lagophthalmos) has become covered with thick, epidermoid epithelium; and although the xerosis bacillus is often found it is not in all cases the chief cause of the epithelial changes.

H. V. Dutrow (*Proc. Canal Zone Med. Ass'n.*, pt. I, Vol. IV, 1914) has reported three cases of *xerosis epithelialis with involvement of the cornea,* in which the xerosis bacillus was found. They were seen in well-nourished individuals, aged 25, 22 and 30 years respectively. The ordinary methods of treatment had been of no avail, and the resulting vision ranged from a practically useless eye, or the counting of fingers, to 20/70. Dutrow gives a tabulation of a bacteriologic examination of forty cases, to determine the incidence of the bacillus xerosis. This examination included Americans, Europeans and negroes. The cultures from the left eye were negative in Americans, while 15 per cent. were positive in European patients. Twenty per cent. of the cultures taken from the right eye of the American patients were positive, while those from the European patients were negative. Cultures taken from the eyes of negroes revealed the bacillus xerosis in either eye, but not in the same patient. In 10 per cent. of the latter cases, an unidentified, biscuit-shaped diplococcus was found associated with the bacillus xerosis.

Dutoit is of the opinion that the bacillus xerosis is the etiologic factor in the keratomalacia of adults. He furthermore believes it important to build up the general health of these patients, and though he is not sure as to the therapeutic value of hexamethylenamin (urotropin) in this disease, he does not hesitate to recommend it in conjunction with tonics and a full diet with extras.

See, also, **Keratomalacia**; as well as **Cornea, Infantile ulceration of the,** p. 3378, Vol. V of this *Encyclopedia.*

The curious association of nyctalopia (q. v.) with xerosis of the conjunctiva has been widely reported. Landolt (*Oph. Year-Book,* p. 130, 1909) pointed out that the *syndrome of hemeralopia* with patches of xerosis on the conjunctiva, first described by Bitot, affects individuals exposed to poor conditions of hygiene and nutrition. It is therefore likely to occur in epidemic fashion among communities subject to such conditions. Prolonged physical exertion, and insufficient or exclusively vegetable food, are important causative factors; hence its occurrence among gangs of South American slaves and in prisons. Landolt reports a case in a recently liberated convict, in whom a cure was effected by merely placing the patient upon a full diet.

M. L. Hepburn (*Medical Press,* Mar. 16, 1910) believes that the hitherto accepted theory of nyctalopia in xerosis, namely, torpor of the retina due to general malnutrition, cannot be justified either by the condition of the patient or by the presence of the ordinary signs of defective calculation in the retina. A more probable explanation of the night-blindness is that certain rays of light act prejudicially on the visual purple, causing retardation of the normal metabolism, a theory borne out by the occurrence of this complaint during the months from May to September, when the intensity of the rays of light is presumably at its greatest. The relationship between the xerotic patches and the night-blindness presents many difficulties, and while the connection between the two seems to be a very close one, a common cause is not easy to find. It is suggested, however, that the same rays of light which influence the visual purple act in some way on the conjunctival mucous glands, inhibiting their secretory function; and in support of this it is found that during the continuance of the xerosis patches the night-blindness persists, whereas when the former is removed, the latter disappears also.

The treatment adopted varied considerably, since it was found that many remedies produced an amelioration of the symptoms, though the time they took to act differed according to the special method employed. Some rely on external remedies alone, while others strongly advocate drugs internally without any local application whatever. Bandaging the eyes for a short time has been known to give relief, and whatever treatment may be used must evidently not only modify the action of the special rays of light on the conjunctiva, but also their path through the pupil to the retina, since in no other way can simultaneous improvement in the prominent symptoms be explained. Arising out of the discussion of this subject, it appears that there is some reason for thinking that congenital night-blindness, xerosis of the conjunctiva and night-blindness, and the night-blindness of malnutrition may be due to a common cause.

Von Hippel (1913) writes of an epidemic of hemeralopia with xerosis which occurred in the spring of 1912 in Saxony and Thuringia. Of eighty-two cases collected by von Hippel, sixty-eight were males. More than one-half occurred in youths under 20 years. In forty-nine cases the nutrition of the patients was very bad; in sixteen it was good; in four no change from normal was noted. Aside from diminution of hemoglobin (under 45 per cent.) and in two cases lymphocytosis, no pathological changes were noted. The treatment varied, but in general consisted in bandaging the eyes, improving the nutrition, the administration of tonics and in some cases cod-liver oil. The effect of the treatment was decided. In von Hippel's own cases the symptoms disappeared on the average in one week. The shortest course was three days. Two factors were concerned in the causation of the epidemic, dazzling and malnutrition. As the result of treatment of a number of cases of xerosis conjunctivæ, with hemeralopia and keratomalacia, Ishihara asserts that cod-liver oil is a specific. Eel oil and olive oil exert a favorable influence. He believes the disease to be due to an insufficiency of fatty substances in the blood.

W. T. Shoemaker reported, in 1909, a case of xerosis of the conjunctiva in a man aged 43, the lesion consisting of a slightly elevated, greasy looking growth, 4 mm. in diameter, situated at the corneoscleral margin on the temporal side. Bacteriological examination revealed quantities of xerosis bacilli and staphylococci. Thorough cauterization of the area resulted in cure, and Shoemaker recommends this treatment, together with proper food, hygienic surroundings, and the internal administration of iron.

Herbert points out that in many cases of xerosis secondary to cicatricial degeneration of the conjunctiva from old trachoma, the upper portion of the cornea covered by the upper lid is not dry, but is opaque from old pannus and insensitive. This loss of sensation is found in nearly all cases of old, inactive pannus. He says further that eyes affected with xerosis secondary to trachoma are those more or less exposed by defective blinking movements, due to the reduced sensibility brought about primarily by old general pannus of both eyes, and sometimes it is difficult to say in a given case which has been the more influential factor in the development of the xerosis, the cicatricial changes in the conjunctiva or the pannus.

Magnani advocates for the relief of xerophthalmos complete tarsorrhaphy according to Buller's method, leaving a small central slit, however, for vision. This operation is followed by improvement of vision, and is especially valuable when both eyes are affected.

Kaz (*Oph. Year-Book,* p. 102, 1916) successfully treated cases of trachoma blindness, pannus, xerophthalmos, lagophthalmos and symblepharon with celluloid films. In xerophthalmos a celluloid film is inserted and removed daily, or on every third day, as required, to keep the eye clean. In pannus only a strip of celluloid is introduced beneath the upper lid and the eye bandaged. The material used is a special form of celluloid for medicinal use, "cellon," 0.1 or 0.003 mm. thick. His conclusions are: 1. That celluloid skin when properly applied is well borne by the eye. 2. In xerophthalmos of trachoma the plate softens and a complete apposition between the plate and the surface of the cornea is secured. 3. By placing a film strip under the upper lid an appreciable clearing of the opaque cornea results. 4. As the causes of blindness in trachoma are pannus and xerophthalmos, we have a means of averting it by the use of celluloid films.

Xerosis. Abnormal dryness, as of the eye or of the skin. See **Xerophthalmia.**

Xerosis bacillus. See pp. 747 and 780, Vol. II of this *Encyclopedia.*

Xerosis epithelialis. See **Xerophthalmia.**

Xerosis glabra. Partial or local xerosis as distinguished from xerosis totalis.

Xerosis infantilis. See *Xerosis epithelialis,* under **Xerophthalmia.**

Xerosis of the conjunctiva. See **Xerophthalmia.**

Xerosis of the cornea. See **Xerophthalmia**; as well as **Keratomalacia,** p. 6829, Vol. IX and **Keratitis e lagophthalmo,** of this *Encyclopedia.*

Xerosis, Parenchymatous. See **Xerophthalmia.**

Xerosis squamosa. XEROSIS TOTALIS. The dry, epithelial form of xerophthalmia, which affects both the palpebral and ocular conjunctivæ and cornea.

Xerosis superficialis. Xerophthalmia due to exposure of the eyeball to the air; epithelial xerosis.

Xerosis totalis. See **Xerosis squamosa.**

Xerosis triangularis. See *Xerosis epithelialis,* under **Xerophthalmia.**

Xerotic keratitis. XEROTIC KERATOSIS. See **Keratomalacia.** Also consult **Keratitis e lagophthalmo** herein.

X-rays. ROENTGEN RAYS. This subject, of such extreme importance to the ophthalmic surgeon, has already been discussed under numerous captions in this work. See, e. g., **Electricity in ophthalmology,** p. 4192, Vol. VI; **Radiography,** p. 10847, Vol. XIV; under **Localization of foreign bodies,** p. 7503, Vol. X; **Fluoroscope,** p. 5232, Vol. VII; **Roentgen rays; Radiotherapy,** p. 10849, and under **Radium,** p. 10851, Vol. XIV of this *Encyclopedia*—that furnish a fair account of the employment of these agents in ophthalmology. To what is there given a few later observations are here added.

The following is a sketch of ophthalmic uses of the x-rays from 1895 to 1913. Additional matter follows in chronological order.

Since their discovery by Roentgen in 1895, the x-rays have taken a position of ever-increasing importance in all branches of surgery, to which ophthalmology has been no exception. The rays are formed by the discharge of a high tension electric current through a vacuum, in suitably prepared tubes, and are generated by the cathode rays impinging upon a solid object, the anode, from which latter point they are given forth in all directions. These rays produce shadows, cause fluorescence, and have a chemical action on a photographic film. They penetrate, in different degrees, substances which are opaque to light, which property gives them their peculiar value in the localization of foreign bodies in the eye, and have a further marked therapeutic effect on certain morbid processes, the exact nature of which is not yet fully understood.

Equipment required for developing the x-rays. The various parts of an x-ray equipment are the generating apparatus, consisting of an induction coil, or a static machine, or high frequency apparatus, with a vacuum tube and its holder; and the receiving screen, which is either a fluorescent screen (fluoroscope) or a photographic plate.

The static machine, which is too well known to require special description, is in many respects convenient, but requires to be run by an electric or water motor and is, therefore, more troublesome than the induction coil. The tubes excited by it are not used up so quickly as are those excited by a coil. See **Electricity in ophthalmology.**

The induction coil, or *high frequency apparatus* may be run by a current from a primary battery, by a storage battery charged by gravity cells or from the street main, by a dynamo which generates a continuous or alternating current of high or low voltage, or directly from the street main with a continuous or alternating current. At the Manhattan Eye, Ear and Throat Hospital (N. Y.), the induction coil of the Ruhmkorff type is used, with a continuous current from the hospital dynamo of 110 volts.

The vacuum tube, which is perhaps the most important part of the equipment, and certainly the most difficult to keep in proper condition, consists of a glass bulb about 10 cm. in diameter, in the interior of which are two terminals—one of aluminum, the cathode; and one of copper faced with platinum, the anode. Sometimes a third is added—the anti-cathode—which is usually made of platinum alloyed with iridium. A palladium wire connected with the exterior is also present, and is protected by a glass cap. This wire is used for lowering the vacuum in the tube, should this become too high. The glass cap is removed and the wire is heated by means of an alcohol flame, thus generating a certain amount of gas in the interior of the tube. The rays require only a certain amount of gas in the tube for their proper transmission, and if there is too much the tube is said to be "low" and the rays are lacking in penetrative power. The low tube is more bluish in color as the rays are passed through. It is made higher by passing a reverse current through the anode and anti-cathode. On the other hand, if the vacuum becomes too rare, the tube is said to be too "high" or "hard," and there is a greater resistance to the passage of the rays, which, as a consequence, have less strength and penetrating power. This is shown by the low reading on the milliam-meter and the fact that the spark jumps across the spark-gap (rather than to go by its usual route), even if the length of the spark gap be very much increased.

A variety of good tubes are manufactured at the present time, and it is hardly desirable in the present connection to describe them in detail, but it may be said that one of the prime requisites is to have a sufficient number of tubes so that each may be allowed a period of quiescence. The vacuum tube is a sensitive affair, and while each one should receive enough use to keep it in condition, any attempt to exact more service from it is certain to result in hitches and difficulties, and poor penetration and poor results. At times the tube will go higher and higher as it is used, the milliam-meter will give a lower and lower reading, and finally discharge occurs around the external surface of the tube. Under these circumstances it is better to resort to another tube and allow the refractory one to rest for a period of several days. A very useful device is a wire "regulator" with two arms. This is applied to the tube so as to cause a sparking, which gives off a certain amount of heat and lowers the vacuum.

The penetration of the tube may be measured by a little disc of aluminum with a silver center, known to manufacturers as a "penetrometer." This has little blocks of different thicknesses, numbered from one to twelve, around the circumference, and when viewed with the fluoroscope some idea can be gained of the power of the tube by comparing the blocks with the central disc of silver which is taken as a standard. Thus, if the central disc is the same shade as the block marked "7," we say that the tube has a penetration of seven. For fluoroscopic work, it is scarcely possible to have too great a penetration, but for photographic work the usual laws of the action of light obtain and too great a penetration results in reduction of the photographic plate everywhere and less contrast. The photographic principle that it is easier to work with a moderate light and a long exposure than with a strong light and a short exposure holds good here, for with a short exposure any error in time is proportionately greater. For thick objects, as in the photography of the shadow of a foreign body in the eye, a penetration of about seven is best. Usually, however, the experienced operator learns to judge of the penetrative power of the tube by the yellowish-green "fluorescent" shade which is present when the tube is working properly.

The tube holder is composed of an upright standard with an adjustable arm which grasps the tube between curved, felt-covered holders. Two side arms are added for the purpose of holding the wires and of keeping them away from the tube to avoid cross-circuiting. In the holder which is used for the localization of foreign bodies in the eye, it is essential that a graduated scale should be added and that the arm allow of a movement of the tube along measured lines, without lateral displacement, which would lead to error. In the Brickner holder there are two separate scales; one on the upright to measure the vertical displacement; the other on the arm, to measure the lateral displacement. The tube may thus be displaced up and down, or sideways, by turning the large handscrews, but is always in the same plane.

The fluoroscope. This instrument consists of a pyramidal box with an opening at one end which is so shaped as to fit closely around the eyes of the observer and exclude the light in the room, while the other end is closed by the fluorescent screen, which is made by coating one side of a piece of cardboard with crystals of tungstate of calcium or with platino-cyanide of barium. The x-rays have the power of rendering these chemicals fluorescent in greater or less degree as they are interrupted in their passage to the screen, so that if an object be held between the rays and the screen a shadow will be formed which shows certain details very well. For flat, thin objects the fluorescent screen is very useful, but for the delicate "detail" work required in the situation of the eye, it is far inferior to the photographic plate. See, also, p. 5233, Vol. VII of this *Encyclopedia.*

The photographic plate should be one of thin emulsion, i. e., a quick plate, and should not be too old. Almost any reliable plate answers well for this purpose—Lumiere, Carbutt, Seed, Cramer, etc. They are best enclosed first in a black envelope and then in an orange one, so that no holder is necessary. In using such a plate, it is simply placed in position beside or under the head and the light-proof envelopes are readily penetrated by the ray. While in the room with the machine, they should be kept in a box lined with sheet lead, 3 mm. thick, and only brought out when the exposure is to be made. It is particularly important that these delicate plates be kept free from moisture, and if it is necessary to make the exposure with the patient's face or any part of the skin pressing on the envelope, a thin sheet of rubber should be interposed so that the perspiration will not penetrate the envelopes.

Developing. In the development of the plate the ordinary rules of photography are to be followed. It is always best, in order to ensure delicacy of detail, to develop the plate rather slowly and to allow the image to come up with the least possible forcing. Hydroquinone or metol-hydro give good results and are easily handled. The temperature of the developer should be about 70° F., although this need not be exact. If the time of the exposure has been correct, any standard mixture of the above solutions will give good results, for in x-ray work as in ordinary photography, it is easy to develop a correctly exposed plate but very difficult to secure equally good results with an incorrectly exposed one. A 10 per cent. solution of bromide of potassium should always be kept on hand, so that if the plate starts to develop too rapidly, in the case of over-exposure, a few drops may be added and the image restrained. This procedure will give a certain amount of contrast to what would otherwise be a flat, weak plate. If the plate be under-exposed, which is shown by the image coming up very slowly, the only thing to be done is to continue the development in a very feeble light for a long period, so as to force the image up as much as possible. Strengthening the developer is seldom effective.

Printing. Occasionally it is desired to print from the negative, and when this is the case the old silver print or glossy velox gives the best results. It must not be forgotten, however, that no printing process reproduces all the details of the negative without some loss, and the transparent negative gives the best image from which to interpret the details; so that for practical purposes printing is unnecessary. Moreover, in the print, the situation of greatest tissue density, which is usually the most interesting part of the picture, is the darkest, while in the negative it is the lightest—a point which has obvious advantages. A transparency loses less detail than a print, but is open to the same objections. The best plan is to use the direct negative for the examination, illuminated by a box with a ground glass plate in the front and an electric light within, the intensity of which can be controlled by a rheostat. Certain "thin" negatives show best with feeble illumination, so the rheostat control is necessary.

Uses of the X-ray in ocular practice. In the present consideration the *X*-rays have three principal uses: 1st. In the *treatment* of various ocular lesions. 2nd. In the *diagnosis* of sinus disease or tumors. 3rd. In the *localization* of foreign bodies in the globe or orbit.

Treatment of ocular disease by the X-rays. A large number of diseases of the eye and its adnexa have been treated by exposure to the rays, as epithelioma, lupus, trachoma, sarcoma, corneal scars, detachment of the retina, cataract, optic atrophy, etc. Much of this work has been directed by the suggestions of experience in *X*-ray burns and has been along logical lines, and has been attended by a marked degree of success. In other conditions the treatment has been purely experimental, and evidence is wanting to establish its value. It may be said in general that the most favorable results have been obtained in superficial malignant processes—of which epithelioma is the best instance—in superficial ulcerative processes, as in lupus, and in certain milder proliferations—as in keloid, papilloma and trachoma. In all these the action is probably by the production of inflammation with breaking up of the tissues exposed, though a variety of opinions are held and the question is by no means settled. The treatment is most apt to be successful where the condition is superficial and the rays can be directly applied to the diseased area. A special form of tube should be used, which is usually long and narrow and made of glass which contains a large proportion of lead, with a small area of ordinary glass in the end, so that the operator and the other parts of the patient's skin do not receive the rays. These small tubes may be applied directly to the area, or a large tube may be placed 30 to 50 cm. away from the patient. If a large tube is used, the area surrounding the area of disease should be covered by a lead plate so as to avoid burning the tissues. The first exposure should be limited to five minutes, though, if no bad symptoms occur, this may be gradually lengthened to ten or even fifteen minutes. The treatments should not be given more frequently than three times a week, and if there is any indication of especial susceptibility on the patient's part, it is better to extend the time in order to avoid a cumulative effect. While burns from single exposures are very rare, in repeated exposures in the course of treatment, burns are very apt to occur unless the case is handled with caution. The skin should be carefully watched for any redness, "shiny" appearance, or pigmentation, and any suspicious appearance should be the signal for the cessation of treatment until the symptoms subside—unless, indeed, in the operator's opinion, the treatment should be pushed, even at some risk. Keinbock describes four degrees of acute dermatitis from this cause. The first appears twelve to sixteen days after exposure, as a rule. The hair loosens and falls out, leaving the skin smooth and bald. Some months—perhaps three or four—after the onset, complete return to the normal takes place. In cases of the second degree, the latent period is shorter. There is slight swelling with hyperemia. The skin becomes light-red, then dark-red, and finally scales off. Complete recovery ultimately takes place, though some pigmentation may remain. In the third degree, blisters or even extensive exfoliation may occur; while in the fourth degree there is dry necrosis of the tissues. Recovery takes place only with the formation of scar tissue in the third and fourth degrees, and is sometimes extremely protracted.

The diagnosis of sinus disease or tumors by means of the X-rays. Recently numerous attempts have been made to utilize the *X*-rays in the diagnosis of purulent collections in the frontal, ethmoidal, and other sinuses, and for the purpose of locating and aiding in the diagnosis of growths in and near the eye and orbit. This work presents peculiar difficulties in that the contrast in the density of the tissues concerned is not great, a great thickness of tissue has to be penetrated, and, as a rule, a "perspective" view is given which is difficult to interpret on account of the "forest" of bony structures seen. Views of the frontal sinuses and surrounding parts are best taken with the plate on the table, the patient lying face down upon the plate and the tube at a distance of 40 cm. above the back of the head. In this way the shadows of the anterior part of the orbits show most strongly, while the structures farther back are less definite and "shade off" so as to interfere as little as possible with the picture. The tube is placed at the distance mentioned for the reason that the farther away it is placed the more distinct will be the shadows cast by objects close to the plate. Of course the time of exposure must be increased in proportion as the tube is withdrawn from the head. For negatives of this character, an exposure of several seconds is required depending on the strength of the coil used. The chief point in the diagnosis of sinus disease is the difference in density between the affected side and the other, which is assumed to be normal, and this point is undoubtedly of great value. It must be remembered, however, that all that can be safely assumed, when one side is darker, is that there is a difference in density between the two sides; the cause of this difference must be inferred from other symptoms. On the other hand, if both sides are equally clear, it is highly probable that the sinuses are free of pus or other dense fluid. On account of the great variation in the size of the sinuses, exact knowledge of their anatomy is in any event of great value.

In the diagnosis of growths of the orbit or its neighborhood, it is best to take the negative at an angle—either from the side, obliquely forward, or from behind forward—so as to avoid a great thickness of tissue and its resulting confusion. Even under the most favorable circumstances, however, the results are not always satisfactory, and the plates must be interpreted by an experienced eye to be of any value. The density of orbital sarcomata and other growths is so little greater than the surrounding tissue, and the shadow is so masked by the bony structures that even when the negative is of the highest order of excellence it is difficult to be positive as to the significance of the appearances. It is best to adjust the tube at such an angle that as clear a space as possible is obtained, and then to give as short an exposure as is possible, to secure the requisite penetration. Osteomata, or variations in the osseous structures are, of course, seen very well.—(E. S. T.)

Valuable as is a careful application of the X-ray in localizing ocular lesions and foreign bodies its defects—*generally of technique*—have been shown ever since it came into general use. Two cases illustrating the defects of the Röntgen ray in this respect were reported by Robert Randolph (*Prac. Med. Series*, Eye, p. 150, 1912). In the first instance the foreign body was protruding from the eyeball behind, well out into the orbit and about half an inch to the nasal side of the optic nerve. It was a little thicker in one part, and the part which lay outside of the eye was emmeshed in a tough capsule. Three-fourths of it lay without the eye, while the inner end was sticking through the retina. The man had carried the steel in his eye for nineteen years and had suffered no inconvenience other than blindness. Recent injury had taxed the eye beyond its endurance, as evidenced by the recurrent attacks of inflammation, which made impossible the further retention of the piece of steel. But for this injury he no doubt would have carried the sliver of steel the rest of his life.

In case two the writer was almost certain that the eye contained a foreign body, from the character of the corneal wound, from what was apparently a wound of the iris and from the hazy media. The eye got slowly worse. The pupil became blocked, and after a month's treatment there was still pericorneal redness and the tension was minus. Before enucleating the eye two additional plates were made, but with negative results. The eye was removed, and far back in the vitreous, surrounded by a mass of exudate, was an irregularly shaped bit of steel.

The unreliability of *X*-ray localization in some instances is illustrated in a case reported by Ring (*Oph. Year-Book,* 1918). One *X*-ray plate indicated the foreign body well behind the eyeball near the optic nerve. Ophthalmoscopic evidence having been secured of its presence in the fundus, the picture taken by another operator showed it within the eyeball, near the nerve entrance. The mistake of locating a foreign body outside the eye, which is really within it, has been made so frequently that there would appear to be a general tendency in that direction. This may be due to failure to allow properly for the divergence of the rays casting the shadow. The diagrams are made the size of the eyeball, but the shadow cast by diverging rays is necessarily larger.

Attention is called to a still more serious error of *X*-ray diagnosis by a case reported by Bachstez. In this case there was much evidence pointing to a tumor of the hypophysis, and the *X*-ray picture showed very marked enlargement of the sella turcica. On the support of such evidence a radical operation was done, and the patient died of basilar meningitis. Post-morten examination showed brain tumors, angiosarcomas, chronic internal hydrocephalus, atrophy of the hypophysis with marked widening and deepening of the sella turcica, and atrophy of its walls.

As has been said the Röntgen rays have been employed therapeutically in a great many diseases of the eyes. The following instances are among the most successful and most important.

X-rays in blastomycetic dermatitis. The *X*-rays form one of the most effective means, in conjunction with potassium iodide internally, of combatting this disease. See p. 1013, Vol. II of this *Encyclopedia.*

X-rays in tuberculosis of conjunctiva. This therapeutic application of the Roentgen ray is probably the most reliable local means (radium, perhaps, excepted) we possess of curing these cases. See p. 3066, Vol. IV of this *Encyclopedia.*

X-rays in tumors of the eyeball, orbit and brain. Although radium (q. v.) is now regarded as a more convenient, if not more efficacious, agent in the treatment of malignant tumors of the eyeball and orbit—both as a primary application and to prevent recurrence after removal—yet the *X*-rays have shown themselves to be a valuable adjunct to other therapeutic measures. References have already been made to them as a means of diagnosis in ocular neoplasims. See e.g., **Retina, Glioma of the**; and, **Carcinoma of the orbit,** p. 1412, Vol. II of this *Encyclopedia.*

F. Terrien (*Archives d'Ophtalm.*, Sept., 1916; review by Lawford in the *Br. Journ. of Ophthalm.*, p. 322, May, 1917), remarks that the employment of radiography in tumors of the brain has seldom proved helpful in diagnosis. In tumors of the hypophysis, however, owing to the alterations induced in the sella turcica, its diagnostic value is fully established. Surgical measures for dealing with tumors of the hypophysis are so generally unsuccessful that radio-therapy, in addition to the administration of suitable drugs, is well worthy of consideration. This method of treatment has been recommended by de Lapersonne and Cantonnet, Gramegna, Béclère, and Jaugeas. The action of *X*-rays on epithelioma, sarcoma, and lymphoma in other situations being well known, it seems natural to submit tumors of the hypophysis to their influence. A certain number of cases have been successfully treated by this means.

Terrien has collected the published records of hypophyseal tumor treated by the application of *X*-rays; the number so obtained, including his own, is ten.

The *technique* followed by Terrien is that described by Béclère (*Journal de Radiologie,* 1914, No. 1). Two paths have been utilized by which the *X*-rays may reach the hypophysis; one from the mouth, the other from the surface of the skull. The buccal path is the most direct and offers a relatively thin layer of obstructing tissue, but the size of the buccal cavity limits the dimensions of the cylinder, especially as when in the mouth the tube must be directed obliquely upwards. Moreover, it is difficult to maintain the tube in position for any length of time.

Béelère advises that the employment of the buccal path should be supplementary to that of the cutaneous through the front-temporal region; by this latter method the dose which reaches the tumor can be doubled or quadrupled by reason of the many possible points of application on the surface of the skull. The best positions are the two temporal fossæ, owing to the thinness of their bony wall.

Although the author gives a description of the methods of application of the *X*-rays, Béclère's paper referred to may be consulted for more detailed instructions, the treatment should be undertaken by an expert radiographer.

In all the cases the results of treatment were encouraging; in some the improvement in the acuity of vision and enlargement of the fields was very marked, but in two of the eight earlier cases the gain was only temporary.

X-ray treatment was adopted in two new cases. Perimetric examination after each series of applications showed an increase in the extent of the fields, especially of the left, with diminution and ultimate disappearance of the paracentral scotoma in the right field.

If, as seems probable, radio-therapy proves a valuable adjunct to, or in some instances an effective substitute for, organotherapy, it adds materially to the means of dealing with a serious and often intractable malady.

That radio-therapy is applicable to all cases of hypophyseal disease need scarcely be contradicted. Béclère, from his experience, has formulated certain indications and contra-indications.

In the group of cases, sometimes termed the ophthalmic type of tumor of the hypophysis, in which the symptoms are purely local and due to compression of contiguous structures by the growth, radiotherapy should be employed; its chances of success are greater if treatment is begun in an early stage, before much destruction of nerve tissue has occurred. In the group in which there are also distant trophic changes, gigantism and acromegaly, the employment of *X*-rays is indicated only at the commencement and during the progressive period of the disease. *i.e.*, during the stage of hyperplasia and hyperpituitarism. In the late stage, marked by an arrest of hyperosteogenesis, loss of muscular power, somnolence, cerebral torpor, and loss of hair, radio-therapy is contra-indicated.

A. C. Snell (*Trans. Amer. Ophthal. Society,* Vol. XIV, Part ii, p. 556, 1916) has reported the treatment of an epibulbar melanosarcoma of the limbus which completely disappeared under *X*-ray treatments.

A man, aged 30 years, had a dark, lobulated growth at the limbus corneæ. V.=20/20, although the mass slightly encroached upon the inner edge of the pupil. The condition had commenced five years before, and had been removed upon five different occasions. The patient, indeed, had been advised to have the eye enucleated in case of recurrence. Between October 31st, 1913, and January 31st, 1914, the *X*-rays were applied on twelve occasions, and a saturated solution of boric acid was kept constantly flowing over the cornea during each exposure. A medium soft tube was employed, two to five minutes being the time of exposure. The tube was placed as close to the eye as the glass cone would permit. Improvement was noted after the fourth treatment, which was discontinued when two-thirds of the area was healed. Six weeks after the last application of the *X*-rays, the entire tumor had disappeared. The cornea was clear. A few non-elevated deposits of pale-brownish pigment extended from the limbus into the conjunctiva beyond. Nineteen months after the treatment, the patient was free from trouble.

The growth was reported by E. A. Shumway as a melanotic, epibulbar sarcoma of the limbus.

von Hippel (*Am. Journ. of Ophthalm.*, Aug., 1918) gives an account of the employment of radio-therapy in glioma retinæ and a number of other tumor cases of a more superficial character, the nature of the growth and the character of the result being as follows: large round-celled sarcoma of the orbit, fatal outcome; sarcoma of the lower lid, cure; adenocarcinoma of the maxillary antrum involving the orbit, patient still living after two years but final outcome uncertain; carcinoma of the lower lid involving the orbit, treatment with Roentgen ray after exenteration of the orbit, one year elapsed without recurrence; carcinoma involving both eyelids over the region of the tear sac, cure; carcinoma of the lower lid involving the nose, failure to arrest, but treatment interrupted; epibulbar melanosarcoma, completely successful result as regards the tumor, temporary injury to the cornea; cornu cutaneum of the lower lid, complete cure; tuberculosis of the bulbar conjunctiva involving the lid margin, complete cure.

X-rays in epithelioma of eyelids. See p. 5004, Vol. VII of this *Encyclopedia.*

X-rays in granular conjunctivitis. See **Trachoma.**

X-rays in keloid of eyelid. Although the treatment of this peculiar disease is unsatisfactory the *X*-ray is about the only therapeutic measure that has so far accomplished anything.

Xylol. Dimethylbenzene, a hydrocarbon used chiefly in microscopy as a solvent and clarifier. See p. 6907, Vol. IX of this *Encyclopedia.*

Y

Yarns of Holmgren. See p. 2448, Vol. IV of this *Encyclopedia.*

Yaws. Frambesia. Button scurvy. Verruga peruviana. Buba. Patta. Framosi. This is an epidemic and contagious disease, consisting of an eruption of yellowish or reddish-yellow tubercles, which gradually develop into a moist, exuding fungus without marked constitutional symptoms, or with such only as result from ulceration and prolonged discharge, i.e., debility and prostration. Incubation varies from three to ten weeks, and yaws usually only occurs once in the same individual. Yaws is distinctly a tropical disease, depending for its origin on extreme heat and moisture. The duration of the disease is from two to six months, but if neglected it may last for several years. The treatment consists of tonics, iodide of potassium, and a generous diet. In 1905 Castellani discovered in patients suffering from yaws a protozoon, the *spirochæta pallida,* almost identical with that now known to be the cause of syphilis.—(*Standard Encyclopedia.*) See **Eyelids, Frambesia of the,** p. 5006, Vol. VII, as well as **Aleppo button,** p. 217, Vol. I of this *Encyclopedia.*

Yeast. See **Cerevisine,** p. 1978, Vol. III; also **Deutschmann's yeast serum,** p. 3860, Vol. V of this *Encyclopedia.*

Yellow. Yellow sensation. Yellow color. According to Edridge-Green (*Proceedings of the Phil. Socy.,* Mar. 15, 1913), there is no evidence of the compound nature of the yellow sensation, any effects due to considerable fatigue are due to the subtraction of the fatigued color sensation and the superposition of the after-image on that of the reacting light. This after-image may in certain conditions be seen more clearly in the absence of light than when projected on a surface reflecting light.

The color of spectral light of low luminosity is incompatible with any form of the trichromatic theory, but is exactly what we should expect on the view that yellow is a simple sensation. If a region of pure yellow be isolated in a spectrometer it will appear yellow when the luminosity is gradually diminished until the region appears colorless. The yellow appears less and less saturated but does not incline either to green or orange. If the yellow were compounded of a red and a green sensation it should become greener on diminishing the luminosity because the red of the spectrum disappears much sooner than the green. The red component of the yellow would disappear whilst the green would remain. The luminosity is diminished by moving the light on a photometer bench. The same is found with pure blue which does not incline to either green or violet when the luminosity is diminished.

Yellow-blue blindness. Acyanopsia. Blue blindness. Sometimes called *violet blindness.* A person afflicted with this form of color-blindness sees only red and green, and confuses blue with green, purple with red, violet with gray and orange with yellow. See p. 2429, Vol. IV; and p. 1234, Vol. II of this *Encyclopedia.*

Yellow color of the lens. See **Coloration of the human lens,** p. 2363, Vol. IV of this *Encyclopedia.*

Yellow fever, Eye affections due to. The claim that ocular symptoms properly result from this disease, aside from the icteroid discoloration of the conjunctivæ has not been satisfactorily established.

Yellow glasses. In addition to what is said on this subject on p. 2388, Vol. IV and under **Amber glass,** p. 288, Vol. I of this *Encyclopedia,* Dye (*L'Ophtalm. Provinciale,* Feb. 1918) remarks that in climates and conditions where the glare of light is great it is a frequent custom to use blue, dark, or "London smoke" glasses, but these have the disadvantage of altering the aspect of things and of introducing an obstacle, by the reduction of light, in the way of persons whose vision is not accurate. It is now some time since Motais (Angers) first advocated the substitution of yellow for dark glasses. Persons troubled by glare, whether their eyes are normal or in a pathological condition, find these glasses pleasant to wear, as they give a sensation of calm to the eyes and at the same time, so far from interfering with sight give a feeling of brightness. He concludes that it is not the luminous intensity which determines the injury to the eyes, and not the heat rays which do so, but the more actinic rays which are responsible. He has obtained therefore, with a view to the comfort of the eyes in hot climates, etc., a glass which will cut off as many of the rays at the blueviolet end of the spectrum as possible. For use in any artificial light rich in yellow rays the glasses in his opinion ought to be but feebly tinted: when there is any lesion of the fundus which reduces the visual acuteness, the further diminution, great when blue or dark glasses are used, is only very slight when amber glass is employed. For use in tropical countries the deeper shades of yellow should be used. As an indication of their value Dye gives the illustration of persons consulting a map under the glazing Egyptian sun. This can hardly be done without glasses for the glare, or with them for the loss of illumination, but is quite easy with the yellow glass. They may be made with any focus required, convex, cylindrical, or whatever is needed.

Yellow halo. That ring surrounding the glaucomatous excavation of the nerve head.

Yellow mercuric oxide. YELLOW OXIDE. See **Mercury, Yellow oxide of,** p. 7655, Vol. X of this *Encyclopedia.*

Yellow ointment. See **Mercury, Yellow oxide of,** p. 7655, Vol. X of this *Encyclopedia.*

Yellow precipitate of mercury. See **Mercury, Yellow oxide of.**

Yellow pyoktanin. APYONIN. See **Pyoktanin, Yellow,** p. 10809, Vol. XIV of this *Encyclopedia.*

Yellow root. See **Hydrastis,** p. 6075, Vol. VIII of this *Encyclopedia.*

Yellow spot. MACULA LUTEA. In addition to the material contained in and referred to on p. 7572, Vol. X of this *Encyclopedia,* it may be added here that one of latest anatomical and pathological studies of the macula has been made by W. T. Lister and Gordon Holmes (*Proceedings Royal Soc. of Med., Sec. of Ophthalm.* June, 1916). They believe, from these investigations:

(1) The upper half of each retina is represented in the dorsal, and the lower in the central, part of each visual area. (2) The centre for macular or central vision lies in the posterior extremities of the visual areas, probably on the margins and the lateral surfaces of the occipital poles. (3) That portion of each upper quadrant of the retina in the immediate neighborhood of, and including the adjacent part of, the fovea centralis is represented in the upper and posterior part of the visual area in the hemisphere of the same side, and *vice versa.* (4) The centre for vision subserved by the periphery of the retinæ is probably situated in the anterior end of the visual area, and the serial concentric zones of the retina from the macula to the periphery are probably represented in this order from behind forwards in the visual area.

Yellow-vision. See **Xanthopsia.**

Yellow, Visual. Visual purple that has been bleached by light. See **Xanthopsin.**

Yellow wax. See **Wax.**

Yohimbin. This agent is an alkaloid found mostly in the form of the hydrochloride, as white crystals.

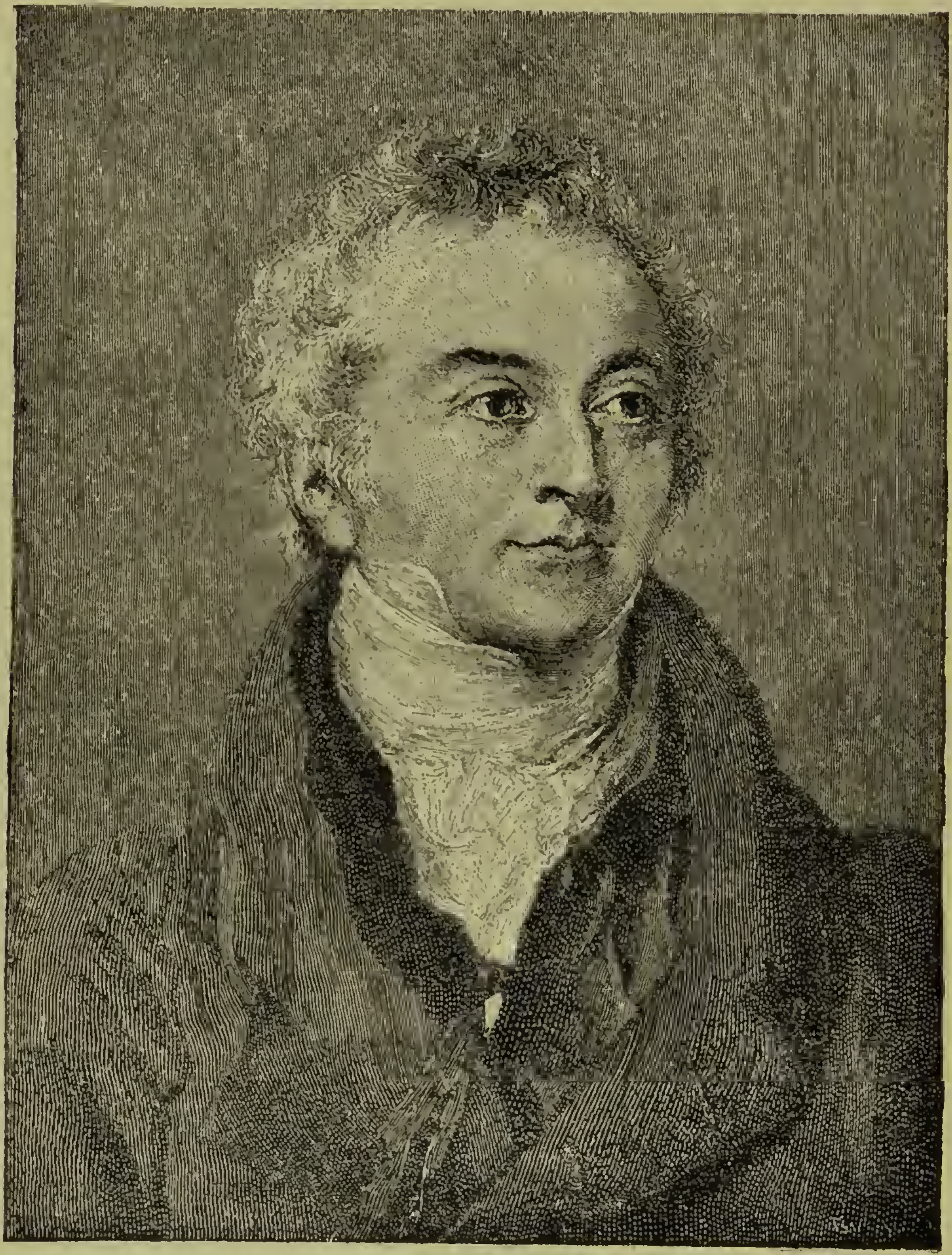
It is derived from the yohimbehe tree of West Africa. Claiborne and Coburn (Wood's *System of Ophthal. Therapeutics,* p. 580) speak of its value as a local anesthetic; it occurs as white, silky crystals, readily soluble in alcohol, but soluble in water only to the extent of 2 per cent. The hydrochloride is the salt usually employed; its aqueous solution deteriorates rapidly and after a week cannot be relied upon; it may, however, be preserved much longer by the addition of a small amount of chloroform. It has been proved non-toxic when injected in doses of 25 cc. of a 1 per cent. solution.

The following conclusions are recorded by the authors: 1. A 2 per cent. solution of yohimbin, either alone or in equal mixture with adrenalin chlorid 1:1000 solution, dropped into the conjunctival cul-de-sac five or six times in ten or fifteen minutes, will produce both corneal and conjunctival anesthesia. Marked anesthesia of the cornea lasts from thirty to forty-five minutes after the last instillation; the conjunctival anesthesia is at no time so profound as the corneal, and disappears several minutes before the latter. 2. There is a slight stinging sensation immediately following the instillation which becomes less and less with each instillation, finally disappearing altogether. 3. The eye becomes immediately suffused and continues red for more than an hour after the last instillation. 4. There is no widening of the palpebral fissure. 5. There is a moderate dilatation of the pupil which comes on several minutes earlier after the last instillation with adrenalin and yohimbin in combination than with yohimbin alone; this lasts in either case from fifteen to twenty minutes. 6. The slight blurring of vision for far and near appears to be due to spherical aberration rather than to paresis of accommodation. Yohimbin alone or in combination with adrenalin is an exceedingly mild mydriatic. 7. Adrenalin when mixed in equal parts with yohimbin in 2 per cent. solution loses its constricting power upon the blood vessels of the palpebral and bulbar conjunctiva. 8. The last mentioned fact suggests the idea that yohimbin may be an antidote to adrenalin chloride. 9. In view of the congestion caused by yohimbin, it cannot be considered the ideal anesthetic for operations involving the conjunctiva or muscles. 10. As an anesthetic in cataract extraction and in iridectomy it would probably be effective. 11. On account of the congestion produced by it, yohimbin is inferior to cocain as an anesthetic in all operations of the eye.

Young-Helmholtz theory. See **Young, Thomas**; as well as **Color-sense,** p. 2426, Vol. IV of this *Encyclopedia.*

Young's rule of dosage. Young's rule is, for children under 12, add 12 to the age and divide the age by the amount thus obtained; thus the dose for 8 years is 8 divided by 8 plus 12=2-5 of the adult dose.

Young, Thomas. Polymath, physician and physicist, one of the most illustrious figures in the history of all sciences. Born at Milverton, Somersetshire, England, June 13, 1773, of Quaker parents, he soon displayed extraordinary precocity. At the age of two, he had learned to read; at four, he had read the *Bible* and *Gulliver's Travels;* when only six years old, he had begun to study Latin. About this time he was sent to a teacher at Bristol, a man of little ability but under whom, nevertheless, our genius made much progress. Two years afterward he was sent to a school at Compton, in Dorsetshire, and here he remained for five years, pursuing with much success the study of physics and mathematics, of Latin and of Greek, and also of French, Italian, Hebrew, Arabic and Persian. He also, for a time, while resi-



Thomas Young.

dent at this school, was busy with botany, calligraphy, and turning on the lathe. With his own young hands he constructed an efficient microscope and a telescope. In 1786, he wrote an analysis of the Greek schools of philosophy.

From 1787 to 1792 he was teaching Greek and Latin to a fellow student. In the first three years of this period he read Homer, Pindar, Epictetus, Longinus, Æschylus, Sophocles, Euripides, Virgil, Ovid, Terence, Cæsar, Sallust, and Cicero; and he also mastered Simpson's *Euclid,* conic sections in algebra, as well as Nicholson's *Introduction to Physics.* By the end of the period he had read Aristophanes, Simpson's *Fluxions,* Newton's *Principia and Optics,* Shakespeare, Corneille and Racine. He wrote his scientific exercises in Latin, French, and Italian, and almost as rapidly and correctly as he could have done in English. Whatever he read, he remembered with the utmost accuracy.

Advised by his uncle, Dr. Richard Brocklesby, a famous physician and Fellow of the Royal Society, he decided to devote his life and energies to medicine. In the autumn of 1792, therefore, he began to study with Baillie, Wm. Cruikshank, and John Hunter. One year later, he entered St. Bartholomew's Hospital. One year later still, he wrote for the Royal Society "*Observations on Vision,*" in which he took the ground (1) that the adjustment of the eye from far objects to near could be accomplished only by a change in the shape of the crystalline lens (i.e., an increase in the convexity of that structure); (2) that the change in question occurs as a result of an inherent muscularity, or contractility, in the lens itself. Neither of the notions was new, and only one of them was true. Descartes had taught the former doctrine, and Leeuwenhoeck the latter. The falsity of the doctrine that the fibres of the lens are muscular in character, was shown just one year later (1794) by Sir Everard Home and the optician Ramsden.

In 1794, the subject of this sketch, though only twenty years of age, and still but a student of medicine, was made a Fellow of the Royal Society. In the fall of this year he went to Edinburgh, there to continue his studies under Gregory, Duncan, Black, Monro, and John Bell. Here, too, he learned the flute and dancing, and received an introduction to German.

In 1795 he proceeded to the University of Göttingen, where he lived in the house of Arnemann, and where, in addition to medicine, he pursued the study of various outside branches. Thus it is said that he became a noted character for his skill in wooden-horse vaulting. He received the degree of Doctor of Philosophy on April 30, 1796, his dissertation being "*De Corporis Humani Viribus Conservatricibus.*" While at Göttingen he also wrote a "lectio cursoria" on the human voice. In this he exhibited and expounded an alphabet devised by him, which consisted of forty-seven letters and which he regarded (perhaps correctly) as being completely adequate for the expression in writing of any sort or kind of language. It was, in fact, intended for a universal alphabet.

In 1797, his maternal uncle, the Dr. Richard Brocklesby already mentioned, died, devising to Young his house, his excellent collection of books and the modest independence of ten thousand pounds. Small as the fortune seems, it was quite sufficient to assure to the world the great discoveries which Young was afterwards to make. Protected from want, the flame of genius burned steadily. Young began to practice in London, at 48 Welbeck Street (an address which he retained for nearly a quarter of a century) and never allowed himself to be so rushed with practice but that his highly original experiments, cogitations, and literary efforts could proceed unhampered. The bounty of Richard Brocklesby had been well bestowed.

In 1799 Young published a paper on sound and light, in which he revised the undulatory theory of light, and placed that theory on a permanent foundation.

In 1801 he published his chief ophthalmologic work, *"The Mechanism of the Eye."* In this remarkable contribution to the world's knowledge, he developed the science of perimetry almost (though not quite) *ab initio* and to a very high degree. The ancients had given a little attention (of a vague and desultory character) to defects in the visual field, and Mariotte, in 1666, had discovered what today is called "the blind spot of Mariotte." In 1708, too, Boerhaave had written a very little on scotomata, both positive and negative: and that was the whole extent of the science of perimetry until the time of Thomas Young. Young also described an original "optometer," based on Father Scheiner's experiment, by which our knowledge of refraction and accommodation was considerably advanced. For example, it was by this instrument that Young made the astounding discovery of ocular astigmatism. He did not, however, (for the truth must be admitted), completely understand the value of his own discovery. He did not, for one thing, perceive the connection of this refractional error with the various symptoms of eye-strain. Nor did he understand that astigmatism could exist in the cornea as well as in the lens. Neither did he think of the correction of this unnatural condition by means of cylindrical lenses. He did, however, lay the foundation for all our future knowledge of this highly important subject, and, but for him, Gersen (in 1810) could not have shown the occurrence of astigmatism in the cornea, or Airy (in 1827) have devised the means of its correction by means of cylindrical lenses.*

In 1802 Young published almost as great a work as that just mentioned. It was called “*On the Theory of Light and Colors,*” and in this book he placed on an even more secure foundation than he had done before the so-called wave, or undulatory, theory of light. Descartes had thought that the passage of light through space takes place instantaneously “as a blind man feels with a stick.” Newton had, with almost equal error, propounded the corpuscular theory, i.e., the teaching that light is caused by the bombardment of the retina by very minute corpuscles emitted from the luminous body. Huygens, in 1678, declared the fundamental principles of the wave theory, the view, that is, that light is produced by the impact on the retina of waves in a so-called “luminous ether”—a fluid of inconceivable lightness and elasticity. This theory was wholly disregarded till the middle of the following century, when the wonderful blind mathematician, Euler (q. v.), developed and clarified it. Still, however, the undulatory theory lay neglected. Then came Young, who developed it still further, brought it to general attention and gave it a permanent place in physical and other scientific literature.

In this same book Young first propounded the theory that the existence of the various colors depends on differences in the rapidity of the different lengths of light-waves. He also declared that, according to his belief, the retina is capable of perceiving, primarily, but three kinds of colors—red, yellow and blue, and that the perception of all the other kinds of colors depends on the various proportions in which these primary color-perceptions are blended. This view, which is called “the Young theory of color vision” was afterwards modified and elaborated by Helmholtz into the so-called “Young-Helmholtz Theory” (q. v.).

In 1807, Young published “*A Course of Lectures in Natural Philosophy and the Mechanical Arts,*” one of the greatest scientific compositions of all time. In this immensely valuable work one of the most important parts is the discussion of color-blindness (Vol. II, p. 315) in which he refers the achromatopsia of Dalton not (as Dalton had done) to a dark-blue color of the vitreous humor, but to an absense from the retina of all those fibres whose function is the perception of red. In this work, too, the author first propounds the electromagnetic theory of light, i.e., in the following language: “The rapid transmission of the electric shock shows that the electric medium is possessed of an elasticity as great as is necessary to be supposed for the propagation of light. Whether the electric ether is to be considered the same with the luminiferous ether, if such a fluid exists, may perhaps at some future time be discovered by experiments; hitherto I have not been able to observe that the refractive power of a fluid undergoes any change by electricity."

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* The name, “astigmatism,” we owe to Whewell (q. v.).

Then, also, in this work is treated the principle of the interference of light, perhaps Young's greatest performance. Grimaldi (q. v.) had, in 1665, first discovered the principle in question, yet had made but little of it. Young, practically, discovered it all anew, gave to it its full validity, proved its truth beyond all manner of question, and showed the different conditions under which the various phenomena of interference can occur. The expression itself, "interference of light," is Young's.

Young also, in the section entitled "*On Vision*," provides the best description of the eye and exposition of its numerous functions that the world had ever seen.

Young's other important contributions to science—outside, that is, our special field—we cannot here discuss. Suffice, therefore, the statement that he made important and lasting discoveries in connection with the motions of the pendulum, with weights and measures, with astronomy, with the expectancy of human life. One of his chief extramedical discoveries was made in the domain of Egyptian hieroglyphics. He established the hieroglyphic values of *p, t, i,* and *n,* and made possible the further achievements of Champollion.

To retrace our steps a little—Young did not receive until 1803 the degree of M.B., and his M.D. not till 1808. In the last named year he was also made a Fellow of the Royal College of Physicians. In 1811 he became physician to St. George's Hospital. In 1822 his portrait (reproduced herewith) was painted by Sir Wm. Lawrence. In 1807 he married Miss Eliza Maxwell, with whom he lived most happily.

Young died May 10, 1829, aged 56, worn out, it seems, by overapplication. He was buried at Farnborough.

Young was never very popular either with his students or with the public. The former found him dry and tedious and much too learned for their limited capacities; the latter found him, at least while trying to minister to the afflicted, altogether too diffident and shy. He seems, furthermore, to have been a little lacking in the sense of humor. All this, however, merely goes to show that even Thomas Young, being human, had limitations.

In addition to the works above mentioned, Young wrote: "*Introduction to Medical Literature*" and a "*Treatise on Consumptive Diseases*" (1815), neither of which was of much value. He also contributed to the "*Supplement*" of the "*Encyclopedia Britannica*" more than sixty useful articles, as well as a number of still more useful ones to the "*Quarterly Review.*"—(T. H. S.)

Yperized eye. See, also, **Toxic amblyopia.** Under the foregoing caption, G. Bonnefon (*Annales d'Oculist.*, Vol. 156, p. 577, 1919; abst. *Am. Journ. Ophthalm.*, p. 543, 1920) reports his experience with eyes affected by dichlorethyl sulphate. He distinguishes 3 periods: (1) The initial or irritative, (2) period of retention, (3) terminal.

(1) This stage may be delayed several hours. There is hyperemia of the conjunctiva, less pronounced than in the case of chlorin gas, and the pain present is less severe. There is a clonic contraction of the orbicularis. The patient walks with his hands covering his eyes. The cornea is never involved.

(2) This stage develops over night. The patient awakens blinded, owing to edema and infiltration of the lid and conjunctiva and the exudate from all the glands of the lid and cul-de-sac. The lids are glued together by the exudate upon the margins of the lid, which rapidly dries and mats the cilia together. The culs-de-sac are distended with fluid, and the ball is bathed in a mixture of tears, exudate and débris. The picture is exactly that of a purulent conjunctivitis in the edematous stage. On attempting to force the lids apart, a yellow fluid spurts from between them, followed by a cry of pain from the patient and the forcible contraction of the orbicularis. Opened by gentle means, the cornea is seen to be intact.

Drawing the lids away from the ball, the conjunctiva of the latter is seen to be of a wine-red color, with a distinct line of demarcation where the margins of the lids touch the ball, more pronounced below than above. This injection gradually fades away inferiorly so that the horizontal meridian seems to be outlined by two bands of anemic conjunctiva. These bands diminish rapidly in size, terminating long before reaching the canthi. The culs-de-sac are intensely injected and edematous. This edema may extend on toward the reddened area of the bulbar conjunctiva, along the palpebral orifice, so that a chemotic area is inserted sometimes between the lids and becomes caught.

(3) After 24 hours of compresses and lavage, with careful toilet of the cilia, the eye becomes greatly improved, only the hyperemia, lachrymation, and photophobia persisting, until in a week the patient is convalescent. In severe cases, however, the symptoms persist, and the photophobia and lachrymation are accentuated. The Meibomian

glands secrete to such an extent that the margins of the lids appear to be covered with zinc oxide ointment. Hordeola and chalazia appear, the latter having a marked tendency to suppurate. These conditions, especially the photophobia and lachrymation may last weeks.

Corneal involvement in man never takes the form of a burn, but always of a keratitis, and is due to microbic invasion during the second stage, when the retained fluid causes maceration of the corneal epithelium. Another cause is the anesthesia of the cornea caused by instillation of cocain, according to official orders. Corneal involvements take the form of (a) simple ulcer, (b) circumscribed abscess of the cornea, (c) hypopyon keratitis, (d) pneumococcic serpigenous ulcer.

In only one case in 30,000 was there hypertension.

The treatment consists, in the first stage of liberal and frequent lavage. Hot compresses for the pain. Second stage—frequent lavage to remove retained fluid and cleansing of the cilia. Avoidance of all collyria, especially cocain. Third stage—alkaline douches have no effect, and isotonic. and bicarbonate solutions seem to accentuate the irritation. Cocain and adrenalin are temporarily palliative. The best results were obtained by the author with a mixture of saturated aqueous solution of sodium sulphate 800 gr., syr. simple, 200 gr., with which the eyes were bathed for ten minutes, 2 to 4 times a day.

Yperman, Jehan. A Flemish physician, of the first half of the 14th century, of moderate ophthalmologic importance. Born in poverty, late in the 13th century, he managed to secure an extensive surgical education under Lisfranc at the College of St. Côme, in Paris. In 1303, or 1304, he settled in his native town of Ypern, East Flanders. For a time he seems to have suffered much adversity. For a brief period he served as army surgeon. Returning to practice, however, he prospered exceedingly, so great, in fact, became his reputation that, according to Hirsch, at the present day, in Flanders, his name is employed generically in the sense of "an unusually skilful physician." Yperman seems to have been especially dextrous in cataract depression. (The extraction operation was not invented till 1748. See **Daviel.**)

Yperman wrote four medical works, all in Latin: two on materia medica, one on internal medicine, and one on surgery. In the latter book are to be found a number of ophthalmologic observations.—(T. H. S.)

Y-rays. These are of the nature of X-rays; they are given off by thorium and uranium also, and are about 100 times more penetrating than the b, being cut down to half value by 6 to 7 cm. of glass or aluminum, and they will pass through almost everything, even 7 centimetres of lead, before being reduced to 1 per cent. of their original strength. As a matter of fact 99 per cent. of the total energy of radium is due to the a rays, the b and y being responsible for the remainder. The quantity of these (y) rays must be so small that the therapeutic effects of radium cannot be due to them.

Y.s. A contraction for yellow spot (the *macula lutea*).

Z.

Zacharias, Master. A Salernian oculist of the 12th century, who seems to have been a man of importance in his day, but concerning whom we have but little knowledge. He studied for three years at Constantinople with Theophilus, who seems to have been body-physician to the Emperor Emmanuel. Returning to Salerno, he practised and taught there, and also wrote a brief work entitled, *"Liber Oculorum, qui Vocatur Sisilacera, id est Secreta Secretorum."*

This little volume (as obscurely written as it is brief) is divided into three "Books": The first of these treats of ocular diagnosis and the underlying principles of oculistic treatment; the second, of the causes of eye-diseases and the special therapy of each disease; the third is a badly arranged collection of prescriptions.

Zacharias was a boaster of the "brass-horn" type, and, apparently, a money-grabber as well. Thus, it would seem that he required an ounce of gold for a single day's treatment of a diseased cornea. He also appears to have been a quack of the P. T. Barnum variety, for he recommends that, when a chalazion has been removed, the oculist should declare that this was a worm which would eventually have destroyed the eye.—(T. H. S.)

Zainab. An Arabian woman oculist who probably lived before the time of Mohammed. All we really know about her is contained in the following passage from Usaibia: "Zainab, the woman physician of the Benu Aud was wise in operations, experienced in the treatment of eye diseases and wounds, and was therefore famous among the Arabians."—(T. H. S.)

Zaleucus. A celebrated philosopher and law giver, a pupil, according to some, of Pythagoras, and certainly the author of the first collection of written laws ever promulgated in Greece. By this, the *Zaleucian Code,* the punishment for adultery consisted in the destruction of both the adulterer's eyes. A son of Zaleucus having been found guilty of adultery, the father destroyed but one of his eyes, suffering the loss of the other eye himself in order that the son "might not wholly walk in darkness." (See Ælianus, *Variæ Historiæ,* xiii, 24; also Valerius Maximus, *Fact. et Dict.,* v. 5, 3.)—(T. H. S.)

Zapfen. (G.) Cones.

Zaraath. (H.) See **Leprosy, Ocular relations of,** p. 7426, Vol. X of this *Encyclopedia.*

Zarrin-Dast. See **Abu Ruh. bin Mansur bin Abi Abdallah bin Mansur alyamani.**

Zehender, Karl Wilhelm von. A famous German ophthalmologist, founder of the well-known "*Klinische Monatsblätter für Augenheilkunde,*" and a co-founder of the *Ophthalmologische Gessellschaft.* Born at Bremen, May 21, 1819, he studied at Munich, Jena, Kiel and Göttingen; at the last-named university receiving his medical degree in 1845. After a brief period of practice as a country physician, he served as military surgeon in the War against Denmark. Returning to civil life, he studied ophthalmology with Friedrich Jaeger in Vienna and A. von Graefe in Berlin. For a time he practised as ophthalmologist in Neustrelitz, and in 1862 removed to Bern to accept the full professorship of ophthalmology in the university at that place. In 1863 he founded the "*Klinische Monatsblätter,*" which, however, was published at Stuttgart. In the very same year, he, together with A. v. Graefe, Arlt, Donders, Hess and Horner, founded the Heidelberg Ophthalmological Society, the first local ophthalmological society in the world.* Until 1895, for 22 years, he was editor of the "*Versammlungsberichte*" of this society. In 1866 he was called to the full professorate at Rostock, where he taught for many years. He died Dec. 31, 1916, well advanced in his 98th year.

Von Zehender's more important ophthalmic writings are as follows: 1. Die Beleuchtung des Innereden Auges. (v. Graefe's *Archiv,* I.) 2. Beobachtungen bei Artificieller Mydriasis (*Ib.,* II.) 3. Ueber Heterocentrische Glasspiegel als Augenspiegel. (*Ib.,* II.) 4. Ueber die Brewster'sche Methode zur Bestimmung der Brechungsexponenten Flüssiger oder Festweicher Substanzen. (*Ib.,* III.) 5. Extirpation eines Orbitaltumors mit Erhaltung des Augapfels. (*Ib.,* IV.) 6. Historische Notiz zur Lehre vom Blinden Fleck. (*Ib.,* X.) 7. Die Accommodations- und Refractions-Anomalien. (Zehender's *Klin. Monatsbl.,* 1866.) 8. Rückblicke auf die Erfolge der Carotis-Unterbindung bei Pulsirenden Orbitalgeschwülsten. (*Ib.,* 1868.) 9. Ueber die Einfhrung des Metrischen Systems in die Lehre von den Refractions-Anomalien des menschl. Auges. (*Ib.,* 1873.) 10. Die Ernährung der Linse. (*Ib.,* 1874.) 11. *Handbuch der Gesammten Augenheilkunde.* (2 vols., 3. Aufl. 1874-76, Stuttgart.) 12. *Lehrbuch der Augenheilkunde für Studirende.* (Stuttgart, 1879.) 13. Ein Vierspiegel-

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* The American Ophthalmological Society was founded in January of the following year.

Apparat zur Bestimmung des Convergenzwinkels der Gesichtslinien. (Zehender's *Klin. Monatsbl.,* 1884.)—(T. H. S.)

Zeiss' glands. The sebaceous follicles of the eye lashes are known as the glands of Zeiss. See **Anatomy of the eye.**

Zeiss' interpupillary measurer. This instrument is also known by the name of Hertel (Graefe's *Archiv f. Ophthal.,* p. 176, 1906) who has described it. See the cut on p. 6542, Vol. IX of this *Encyclopedia.*

Zeozon. A trade name for a salt or derivative of esculin (from the horse chestnut), used in ophthalmic practice for staining the cornea.

F. Pincus (*Archiv. f. Augenheilkunde,* 73, p. 291) remarks that zeozon, a monoxid-derivative of the glycosid esculin, found in the bark of the horse chestnut, was introduced by Unna in the form of a paste for the protection of the skin against undesirable effects of sunlight. Ruhemann has used zeozon water, a 0.3 to 0.5 per cent. solution of the orthooxid derivative of Unna's preparation with boric acid, in 40 cases as eye water against glaring, and reported that all distressing symptoms disappeared after 4 instillations per day.

At the instance of C. Hess, Pincus investigated the properties of zeozon experimentally. He found by spectrographic-photographic methods that a thick layer of zeozon water absorbs the ultra-violet rays, but this it will not do in thin layers. His experiments on rabbits proved without exception that instillations of zeozon water into the eye are not capable of protecting this in any way against the action of ultra-violet rays, a result which with consideration of the physical conditions of absorption of the rays of light by fluids and the physiological processes following the introduction of fluids into the conjunctival sac is to be expected. He therefore warns us against relying on the protection by zeozon water against glaring.

See, also, **Aqua zeozoni,** p. 545, Vol. I of this *Encyclopedia.*

Zerstreuung. (G.) Dispersion.

Zerstreuungskreise. (G.) Circles of dispersion.

Zeune's law of blindness. See Vol. II, page 1198, of this *Encyclopedia.*

Ziegler Magazine for the Blind. See p. 270, Vol. I; and p. 6524, Vol. IX of this *Encyclopedia.*

Zinc. ZINC SALTS. ZINC COMPOUNDS IN OPHTHALMIC PRACTICE. Preparations of zinc salts have from the earliest times been used in ophthalmic surgery and are prescribed either directly as such or are ordered in such chemical combinations as produce them. They are all valuable astringents and when judiciously employed (weak solutions and ointments are preferable at least for Americans!) are of signal value especially in most forms of subacute and chronic conjunctival catarrh. The chief compounds from the ophthalmic standpoint are the sulphate, chloride, borate, oxide, acetate, salicylate, sozoiodolate, iodide and permanganate, all of which are separately discussed in the alphabetical list. All of them, as has been frequently remarked, act as specifics in diplobacillary or angular conjunctivitis.

Most soluble zinc salts are incompatible with alkalies, cyanides, lime water, sulphates, sulphides, and nearly all the vegetable, astringent decoctions and infusions.

A Duane uses zinc chloride or zinc sulphate in varying degrees of concentration, either alone or combined with boric acid, in chronic conjunctivitis of unknown origin, when an astringent effect seems desirable, and, of course, in diplobacillus-conjunctivitis. On the whole he has been disappointed in the action of zinc in conjunctival catarrh and finds many people who cannot bear it even in very weak solutions. A favorite combination with him is: Acid. boric., Sod. borat. āā, 0.50; Zinc. sulph., 0.06; Aquæ dest., 15.00.

For the relief of the smarting and occasional pain following the use of collyria made with zinc sulphate, zinc chloride and other soluble zinc salts H. V. Würdemann advises the addition of ½ per cent. antipyrin or chloretone to these mixtures.

Zinc acetate. ZINCUM ACETICUM, P. G. $Zn(C_2H_3O_2)_2$. This salt is made from commercial zinc oxide, acetic acid and water, and is found in pharmacy as white, soft, pearly scales or plates with an acetous odor and sharp, metallic taste. It is very soluble in water; less so in alcohol.

Owing to its solubility it is useful in collyria and may be used, like the sulphate and chloride, where zinc salts are required. A solution containing a half to two grains to the fluid ounce of water is the usual collyrium for chronic conjunctivitis.

A mixture of zinc acetate 1 part and alumnol (q. v.) 4 parts has been recommended as a good antiseptic. Its trade name is zinol. It is reported to be useful in the Morax-Axenfeld and other forms of conjunctivitis in one-fourth to one per cent. aqueous solution.

Zinc biborate. See **Zinc borate.**

Zinc borate. ZINC TETROBORATE. ZINC BIBORATE. ZINC PYROBORATE. $Zn\ B_4O_7$. This is a white, amorphous powder, very little soluble in water. It is used like zinc oxide as a dusting powder and in 10 per cent. salves in eczema of the lids and in mild forms of blepharitis. When collyria containing zinc sulphate are ordered with free boric acid small quantities of the borate are probably formed.

Zinc chlorid. $Zn\ Cl_2$. This is a whitish, crystalline powder, or it is found as opaque tablets or rods; very deliquescent. It is odorless, has a very caustic taste and is soluble in less than half its weight of water.

In addition to the use of this agent as a paste for escharotic purposes in the treatment of warts, malignant tumors and granular tissue about the eye and for the destruction of the lachrymal sac, it is by some surgeons employed in weak solutions (one-fourth of a grain to the ounce, or 1:500 to 2,000) as an antiseptic and astringent in affections (especially the conjunctivitides) of the external eye. In common with the milder zinc salts it is almost a specific in the Morax-Axenfeld infection. Burgeois and others regard still stronger solutions (1:100 to 20) as of great value for injecting the lachrymal sac in dacryocystitis, especially when that disease is complicated with corneal ulcer.

Harold Gifford advises brushing or swabbing the everted lids in gonorrhœal ophthalmia with a 2 per cent. solution of zinc chloride instead of silver nitrate. He exercises care not to have the solution run into the sac and believes that employed in this fashion twice a day it is superior to the silver salts as an anti-gonococcic remedy.

Zinc-chloride double salt of dimethyl-toluthionine. See **Toluidine blue.**

Zinc dïiodopara-phenosulphonate. See **Sozoiodole-Zinc.**

Zinc, Flowers of. See **Zinc oxide.**

Zinc iodide. ZINCUM IODATUM, P. G. ZnI_2. This is a white, granular, odorless crystalline powder, with a sweetish but sharp metallic taste. It is very deliquescent, decomposes readily and soon acquires the taste and smell of iodine. It is soluble in water and alcohol.

Iodide of zinc is astringent and antiseptic and may be employed like other zinc salts in the treatment of various external diseases of the eye. Its usual dose is one-fifth to one per cent. in water.

Zinc iontophoresis. H. M. Traquair (*Ophthalmic Review,* p. 1, Jan., 1914) gives a full account of this method in the treatment of purulent keratitis (with *ulcus corneæ*). He follows the plan of Wirtz. See **Ionic medication,** p. 6574, Vol. IX, as well as **Cataphoresis,** p. 1438, Vol. II of this *Encyclopedia.* Traquair has employed the remedy in a large number of cases and regards the main points to be considered are the following:

1. Although special apparatus is required the technique is very simple.

2. An electrode 1.5 mm. in diameter and shaped like a thermocautery is very convenient. With this size a dose of 1.5 ma. for 1.5 minutes is enough.

3. Care should be taken to treat thoroughly every portion of the advancing edge of the ulcer.

4. The difficult parts to treat are those where the undermining is very deep and the overhanging tissue thick and tough, and the in-

fected foci, sometimes seen, which project like buds deeply into the cornea. These spots should be scraped with the zinc point with a dose not above 0.5 ma. for 0.5 minutes.

5. Generally speaking the smallest efficient dose should always be used.

6. When the process is not checked it is because the causal organisms have not been properly got at, not because they have proved resistant.

7. Pain may occur, either immediately following the application or some days afterwards, in this case due to iritis. Eucain ointment for the former and atropin for the latter have proved successful remedies. Only in exceptional cases is the treatment followed by severe pain.

8. The method is certainly efficient for mild and moderately severe ulcers.

9. More experience is required before it can be said that zinc iontophoresis is an unfailing remedy in severe cases. It has certainly produced results as good as, or better than might have been expected from the cautery in those severe cases in which it has been used. With or without paracentesis it would appear to be suitable for those advanced cases in which the condition of the cornea renders cauterization inadvisable.

10. The eye may remain red for longer than usual after the ulcer is healed but this circumstance does not indicate any serious condition, and may be neglected.

11. The healthy corneal tissue adjoining the ulcer is not destroyed as it is by the cautery, with the result that thinner and less extensive scars are produced.

12. As far as can be judged from the evidence at hand, the average vision obtained is superior to that following cauterization.

Zinc oxide. Flowers of zinc. Zn O. This salt is a faint, yellowish-white, amphorous powder, insoluble in water.

This preparation of zinc used alone is practically inert except that it forms a useful protective where the epithelium is removed from the skin or a mucous membrane. Mixed with oily substances or incorporated with salves it is a useful adjunct and as such does good service in various forms of blepharitis and eczema of the lids. For this purpose it mixes well with ichthyol, starch and petrolatum, the most useful proportion with the last named being from 2 to 10 per cent. Fick's formula for moist, eczematous patches on the lids probably produces some zinc salicylate: Zinc oxidi, 1.0 (gr. xv); Acid. salicylic., 0.1 (gr. iss); Vaselini, 10.0 (ʒiiss).

In chronic ulcerative blepharitis L. D. Brose prefers the application of the following ointment. Before applying it the crusts are removed from the lid edges at night with tar soap: Pulv. sulphur. precip., Ol. cardini, Pulv. zinci oxidi, āā 1.00; Ol. olivæ, 2.00; Lanolin, 9.00.

Zinc permanganate. Zn $(MnO_4)_2$. This salt occurs as dark, violet-brown, hygroscopic, crystalline granules, similar in appearance to permanganate of potassium and, like it, used as an antiseptic and astringent wash. It is employed as a bactericidal collyrium in 1:1000 to 500 solutions and should from its chemical composition be very useful clinically. The Editor has prescribed it with much benefit as a 1:3,000 solution for the home irrigation of the nasal duct following operation for the relief of lachrymal stricture.

Zinc phenolsulphonate. See **Zinc sulphocarbolate.**

Zinc pyroborate. See **Zinc borate.**

Zinc salicylate. This salt crystallizes in long, satiny needles with a sweetish, styptic taste. It is soluble in 20 parts of cold water; more soluble in alcohol and ether.

Zinc salts. See **Zinc.**

Zinc sozoiodolate. See **Sozoiodole-Zinc.**

Zinc sulphanilate. NIZIN. This agent is a zinc salt of sulphanilic acid, introduced by Burroughs, Wellcome & Co. It is a neutral, white, crystalline substance; readily soluble in water, recommended by Sydney Stephenson in diplobacillary conjunctivitis and in ulcers of the cornea associated with that affection, when employed as a solution containing one to three grains to the ounce of distilled water. He regards it as an efficient substitute for the zinc chloride in common use.

Zinc sulphate. WHITE VITRIOL. ZINCUM SULPHURICUM. VITIOLUM ALBUM. Zn SO_4+7H_2O. From the ophthalmic viewpoint this is the best known salt of zinc. It closely resembles magnesium sulphate (Epsom salts), occurring in large colorless crystals that slowly effloresce in air. It is very soluble in water; insoluble in alcohol; and is an irritant poison

The sulphate is generally regarded as the ideal zinc salt for ophthalmic use. It is prescribed in solutions of from one to 500 to two per cent. All the soluble zinc salts act as specifics in the Morax-Axenfeld conjunctivitis, but as they are decided irritants one should hesitate to employ them in other conjunctival diseases except in the weakest solutions and generally in combination with other agents. In simple conjunctivitis a 1:1,000 solution in distilled water has proved quite strong enough. For such purposes as injection of the sac for dacryocystitis one to three per cent. solutions are recommended. Zinc sulphate is also used as a one per cent. ointment with vaseline and other bases.

In the various forms of catarrhal conjunctivitis Hirschberg uses plain solutions with distilled water, from 1:1,000 to 1:100, according to the desired astringent effects.

It may, of course, be combined with other adjuvants and correctives. For example: Zinc. sulphatis, 0.5 (gr. vii); Tinct. opii, 1.0 (gtt. xv); Aquæ dest., 150.0 (fl℥iv, flʒv); Aquæ fœniculi, 50.0 (fl℥j, ʒjss).

E. A. Dial suggests that if to every pint of boric acid collyrium two grains of zinc sulphate be added it would increase its efficacy in simple hyperemia and catarrh of the conjunctiva.

For the hyperemia of the conjunctiva and the irritative symptoms that sometimes accompany refractive errors and occasionally persist after they have been properly corrected, Hanford McKee prescribes a collyrium containing one-sixteenth of a grain of zinc sulphate to the ounce of water.

As a commentary on the irritant action of zinc salts on the eye, especially when instilled in strong solutions, H. Gjessing (*Norsk Mag. f. Laegevid.*, Aug., 1915) mentions acute glaucoma following an instillation of 1 per cent. zinc sulphate, preceded by a local anesthetic (2 per cent. holocain hydrochloride). Gjessing's patient was a man of 79 subject to acute attacks of glaucoma of the type known as glaucoma with intermittent hemostasis. The tension in the eye had been 53 mm. of mercury. Both holocain and zinc cause transient hyperemia in the conjunctiva.

The Editor believes that the alleged action of holocain in causing or helping to cause acute glaucoma is probably a coincidence. Knowing that any local irritant may precipitate a pending attack of glaucoma it is also conceivable that the zinc in the mixture may have had that effect. That 2 per cent. holocain, which causes comparatively little local reaction, and is not a mydriatic, should be responsible for a glaucoma is highly improbable.

Zinc sulphocarbolate. Zinc sulphophenate. Zinc phenosulphonate. Zn $(C_6H_5SO_4)_2+8H_2O$. This preparation appears as clear, colorless, columnar crystals, or as a fine, white powder, very soluble in water or alcohol. It is a stimulant-astringent and is occasionally employed in 1:200 of distilled water in infections of the anterior ocular segment, especially in chronic diplobacillus inflammations.

L. B. Brose advises the following mixture as a collyrium in simple catarrhal conjunctivitis, two drops to be put into the eye four times a day: Zinci sulphocarbolatis, 0.02; Sol. adrenalin chloridi (1:1000), 0.33; Acidi borici, 0.13; Aquæ camphoræ, Aquæ dest., āā 4.00.

Zinc sulphophenate. See **Zinc sulphocarbolate.**

Zinc teroborate. See **Zinc borate.**

Zincum aceticum. See **Zinc acetate.**

Zincum chloratum. See **Zinc chloride.**

Zincum iodatum. See **Zinc iodide.**

Zincum sulfuricum. See **Zinc sulphate.**

Zinn, Arterial circle of. An arterial network from the pial sheath of the optic nerve anastomoses with a circumpapillary network in the sclera. The latter is derived from the short posterior ciliary arteries and is called the arterial circle of Zinn.

Zinn, Johann Gottfried. A distinguished German anatomist, who discovered the annular ligament of Zinn, and for whom that structure (as well as the zonula of Zinn, which he did not discover) is named. Born at Ansbach, Germany, Dec. 4, 1727, he studied both at Ansbach and in Göttingen, at the latter institution receiving his medical degree in 1749. He at once proceeded to Berlin, where, for several years, he studied anatomy and botany, laying broad and deep the foundations on which his reputation as an anatomist will rest secure forever. In our especial field his most important discoveries were made in connection with the iris and ciliary body, the lens and the ocular system of nerves. In 1753 he removed to Göttingen, to accept the chair of medicine in the University as well as the directorship of the Göttingen Botanical Gardens. In Göttingen he died April 6, 1759, aged only 32.

His most important writings are: 1. De Differentia Fabricae Oculi Humani et Brutorum. (*Abh. d. K. Societät der Wissensch. zu Göttingen,* IV. B.) 2. Observationes quaedam Botanicae et Anatomicae de Vasis Subtilioribus Oculi et Cochleae Auris Internae ad illustr. Werlhofium. (Göttingen, 1753.) 3. Programma de Ligamentis Ciliaribus. (*Ib.,* 1753.) 4. *Descriptio Anatomica Oculi Humani Iconibus Illustrata.* (His masterpiece; Göttingen, 1755.) 5. *Descriptio Plantarum Horti et Agri Goettingensis.* (*Ib.,* 1757.)—(T. H. S.)

Zinn, Ligament of. The suspensory ligament of Zinn is a name for the *zonula of Zinn;* the *annular ligament* of Zinn is quite another affair, being the common tendon, situated at the apex of the orbit and from which the recti muscles take their origin. The latter organ is also described under several appropriate captions.

Zinn, Zonula of. See **Zonula of Zinn.**

Zinol. See **Alumnol,** p. 280, Vol. I; also **Zinc acetate.**

Ziska. A blind Bohemian general, whose name is said to mean "the one-eyed." His real name was John Trocznow. Having lost an eye in battle, he was re-christened "the monocular." At the siege of Rahab, he lost the remaining eye. The story of this calamity runs as follows: "He had reduced the town of Rahab to extremities, when, as he was viewing a part of the works where he intended an assault, an arrow, shot from the wall, struck him in his remaining eye. The wound being thought dangerous, the surgeon of the army proposed his being carried to Prague, where he might have the best advice; in reality, however, they were afraid of being cut to pieces by the troops, if he should die under their hands. When his removal to the capital was resolved on, it was difficult to check the contest among the soldiers, who strove for the honor of carrying their wounded general. At Prague the arrow was extracted, which, being barbed, tore out the eye with it, and it was feared that the fever which succeeded would prove fatal; his life, however, though with difficulty, was saved. As a result of this accident he was condemned to total darkness for the remainder of his life, but the sequel proved that, like Sampson, he was more destructive to the enemies of his country after, than before, his blindness, because Ziska, as he continued to be called even after the loss of the second eye, won many battles, and was even renowned for his own personal prowess. For an account of all these engagements, as well as for the wonderful ways in which this very resourceful blind man dealt with the numerous conspiracies against him, we refer the reader to the various histories of Bohemia.—(T. H. S.)

Zitternder Staar. (G.) Tremulous cataract.

Zodiacal light. The name given to a singular appearance seen after sunset or before sunrise, at all seasons of the year in low latitudes. It is obviously due to illuminated matter surrounding the sun in a very flat lenticular form, nearly coinciding with the plane of the sun's equator, and extending to a distance from the sun greater than that of the earth, since its apex is often seen more than 90° from the sun. The common explanation of the phenomenon is that it consists (like the rings of Saturn) of an immense assemblage of small cosmic masses, such as are continually encountering the earth in the form of aerolites or meteorites.—(*Standard Encyclopedia.*)

Zoetrope. THAUMATROPE. This is a scientific toy by which several pictures of objects or persons in various positions are combined into one visual impression, so as to give the appearance of movement or life. It consists of a hollow cylinder, closed at the lower end, supported on a vertical axis in the center of that end. Round the interior of the cylinder, in its lower part, is a band of pictures of the same object, but varied in succession according to the varied steps of the movement intended to be shown. Round the upper part is a series of narrow slits, equal in number and opposite to the pictures. On revolving the cylinder rapidly and looking through these slits as they pass the eye, the figures of the picture appear as one moving figure. The kinetoscope and kinematograph are developments. When the images are reflected successively from mirrors, giving the appearance of a person or animal in motion, it is called the praxinoscope.—(*Standard Encyclopedia.*) See, also, **Kinetoscope.**

Zoiatria. ZOIATRICS. Veterinary practice.

Zöllner's lines. See p. 10133, Vol. XIII of this *Encyclopedia.*

Zona ophthalmica. Herpes zoster ophthalmicus.

Zone, Ciliary. See **Corneoscleral margin,** p. 3523, Vol. V of this *Encyclopedia.*

Zone, Interpalpebral. That part of the cornea and scleral conjunctiva not generally covered by the lids; that portion of the eyeball seen in the normal eye when the person is looking straight forward.

Zone, Nuclear. That region in the lens substance, along the equator, where growth of the (nuclei of the) lenticular cells takes place.

Zone of the choroid, Capillary. CHORIOCAPILLARIS. See **Capillary zone of the choroid,** p. 1388, Vol. II of this *Encyclopedia.*

Zone of Zinn. The **Zonula of Zinn.**

Zone, Pericorneal. The circumcorneal, pinkish, vascular zone seen in iritis and some other acute diseases of the uveal tract.

Zone, Pupillary. The inner of the two zones of the iris. See **Anatomy of the eye.**

Zone therapy. One of the later systems of pseudo-therapeutics, including an alleged cure of ocular affections, deserves attention here only because of the prominence and publicity which have been given to it by such magazines as "*Everybody's,*" "*The Strand,*" "*The Associated Sunday Magazines,*" and "*Every Week.*" The method is discussed *in extenso* in a book by William H. Fitzgerald, M. D., (the discoverer) and Edwin F. Bowers, M. D., published in 1918 by I. W. Long, of Columbus, Ohio, and entitled "*Zone Therapy, or Relieving Pain and Disease.*"

The fundamental postulate of this "zone therapy" is that the body is divided into therapeutic pressure-zones, five on each half (right and left) of the anterior surface and an equal number on the posterior. "Pressure applied upon the corresponding zones" deadens pain "in more than 98 per cent." of the cases, and "when zone pressure relieves pain it likewise tends to remove the cause of the pain, no matter where this cause originates."

The method is declared to be at least free from all danger. Whether this statement is wholly true may be hereunder inferred.

The following parts of the subject would seem to be of especial interest to ophthalmologists. "*That aching head.* The next time you have a headache, instead of attempting to paralyze the nerves of sensation with an opiate, or a coal-tar 'pain-deadener,' push the headache out through the top of your head. It's surprisingly easy.

“It merely requires that you press your thumb—or, better still, some smooth broad metal surface, as the end of a knife-handle—firmly against the roof of the mouth as nearly as possible under the battle ground—and hold it there for from three to five minutes—by the watch. . . . Headaches and neuralgias, of purely nervous origin, not due to poison from toxic absorption from the bowels, or to constipation or alcoholism, tumors, eye-strain, or some specific organic cause, usually subside under this pressure within a few minutes. 'Tis as easy as lying.”

In the treatment of goitre by zone therapy, “a thin probe, the point of which is wrapped in cotton dipped in a little alcohol, spirits of camphor or camphor water (these seem to increase the 'impulse') is passed through the nostrils to the posterior or back wall of the pharynx. Pressure is made in various spots 'low down' on this wall (a little practice will determine almost the exact spot to probe), until a definite sensation is felt in the region of the goitre. . . . In addition to the treatment on the pharyngeal wall, pressure may be made upon the joints of the thumbs, first and second fingers. Or, if the goitre is a very broad one and extends over into the fourth zone, the ring finger must also be employed. A moderately tight rubber band, worn upon these fingers for ten or fifteen minutes three or four times daily, will also help. Rubber bands may also be worn with benefit upon the toes governing the zones involved. . . . If the theory of eye-strain causation of goitre is true—and it seems quite likely that, in many cases, it may be—pressure therapy may logically be looked for to give satisfactory results. For the effects of eye-strain can undoubtedly be relieved by pressure exerted on the first and second fingers.”

In the chapter entitled, “*Finger pressures for eye troubles,*” the book runs on as follows: “If your eyes pain, close them lightly—or leave them open, if you prefer—and squeeze tightly the knuckles of the first (or index) fingers of both hands. Occasionally, if the eyes are set far apart and extend over into the third zone, the second (or middle) finger must be included in this digital embrace. But as a general rule pressure on the upper and lower surfaces, as well as on the sides of the first and second fingers will, within five minutes, relieve the pain of eye-strain. . . . Yet we have cured optic neuritis by making pressures over the first and second fingers, and over the inferior dental nerve—where it enters the lower jaw bones.

. . . For the benefit of physician readers I should like to add that in treating eye-strain, conjunctivitis, sties, granulated [*sic!*] eyelids. and eye conditions generally, pressures made with a blunt probe on the muco-cutaneous margins (where the skin joins the mucous membrane in the nostrils) affects the second division of the ophthalmic nerve, and assists materially in bringing about a favorable influence in eye troubles."

The very small kernel of truth involved in all these matters need not be pointed out to ophthalmologists.—(T. H. S.)

Zone, Visual. A term used in skiascopy (q. v.) to designate that important area in the center of the pupil that has about the same point of reversal.

Zonula of Zinn. SUSPENSORY LIGAMENT. ZONE OR ZONULA OF ZINN. ZONULA CILIARIS. This structure is described and depicted on p. 377, Vol. I, as well as on p. 5963, Vol. VIII of this *Encyclopedia*. It should not be confounded with the *annular ligament of Zinn*—the common tendon from which the recti muscles arise at the apex of the orbit.

V. Carlini (Graefe's *Archiv f. Ophthalm.*, Vol. 82, I, 1912; abstract in *Annals of Ophthalm.*, p. 785, Oct., 1912) does not regard the zonula of Zinn in the light of a membranous formation but as a complicated system of fibers arising from the surface of the retina ciliaris, most of the fibers inserting in the lens capsule. The space traversed by the fibers is part of the posterior chamber and is filled with ocular fluid.

2. The posterior chamber is bounded in front by the iris, internally by the lens capsule, externally by the retina ciliaris, behind by the vitreous. The zonula fibers divide the chamber into three portions: 1, an anterior portion without fibers (prezonular space of Czermak, or real posterior chamber); 2, a portion traversed by zonula fibers (zonula space of Czermak, canal of Petit of some authors, Hannover's canal); 3, a facultative portion behind the zonula fibers (postzonular space, canal of Petit of some authors).

3. In the structure of the zonula he differentiates, with Garnier, principal and auxiliary fibers. The principal fibers arise from the orbiculus ciliaris and the ciliary processes, and from three main bundles (anterior, middle, and posterior bundle of Salzmann), which insert into the lens capsule. They correspond to the fibræ orbiculæ and ciliocapsulares of Czermak. The auxiliary fibers are of two varieties: those which strengthen the principal fibers, and those which connect more or less distant portions of the retina ciliaris. The latter correspond to the fibræ orbiculociliares and fibræ inter- and intraciliares of Czermak, and the association fibers of Terrien.

4. The zonula fibers for the most part run in a meridional direction. However, circular fibers also exist (Ulrich, Arnold, Claeys, Berger, Salzmann).

5. The zonula fibers decussate before reaching the capsule, the fibers arising posteriorly from the orbiculus ciliaris and ciliary depressions inserting into the anterior surface of the lens, the fibers coming from in front of the processes going to the equator and posterior lens surface. The decussation, however, is only partial, some fibers passing directly from the anterior and posterior portions of the retina ciliaris to the anterior and posterior lens capsule respectively.

6. The zonula fibers are colorless, straight, of glassy appearance, and contain no nucleus. The stronger fibers result from a coalescence of finer fibers; the delicate fibers which undergo no further division are the primitive fibrillæ. Chemically the zonula fibers resemble elastic fibers, but they lack the resisting capacity of elastic fibers. The zonula fibers exhibit no characteristic staining qualities. Nuclear stains are not accepted. However, they take the elastic fiber stain (orcein—Unna, Taenzer, Livini; and resorcin-fuchsin—Weigert) but not to the degree observed in the intima of arteries. They also stain by Weigert's neuroglia method, Mueller's fibers remaining unstained.

The zonula fiber must, therefore, be regarded as a special variety of fiber, although resembling the elastic and neuroglia fiber chemically and in staining qualities.

7. The retina ciliaris (pars ciliaris retinæ) extends from the ora serrata to the iridociliary angle, and consists of two layers of cells, an outer pigmented, and an inner unpigmented. The external layer is the direct continuation of the pigmented layer of the retina. The inner corresponds to the nine remaining layers of the physiologic retina. Both layers consist exclusively of cells, of elements entirely homogeneous.

Neither nucleated supporting fibers (as Berger asserts), nor Terrien's anuclear fiber structure occur in either layer.

The lamina vitreas of the choroid continues beyond the ora serrata and forms the vitreous membrane of the ciliary body, or external vitreous membrane. It is a fibrillary structure representing a condensation of the supporting connective tissue elements.

8. The lamina vitrea interna Bruecki (hyaloid membrane of the pars ciliaris retinæ) is the direct continuation of the limitans interna retinæ.

9. By far the great majority of zonula fibers originate from the pars ciliaris retinæ. The fibers can be followed only as far as the lamina

vitrea interna, which must, therefore, be regarded as the real place of origin. A few finer fibers arise from the vitreous.

10. The zonula fibers are seen just in front of the ora serrata with the first ciliary epithelial cells, becoming more numerous in the direction of the ciliary processes. In the most anterior portion of the pars ciliaris their number decreases, and at the summit of the ciliary processes they have practically disappeared.

11. The posterior boundary of the zonula repeats the serrated form of the ora serrata. The anterior border of the zonula in the adult coincides with the inner edge of the ciliary body (viz., the line corresponding to the greatest elevation of the ciliary body above the level of the inner surface of the sclera); in the newborn it corresponds to the iridociliary-angle, from which also zonula fibers arise.

12. The zonula fibers arise from the orbiculus ciliaris in its whole extent and from the bottom of the ciliary valleys; no fibers spring from the sides and summits of the processes. Occasionally a few stray fibers are seen arising from near the base of the processes.

13. The vitreous is separated anteriorly from the zonula ciliaris by the anterior boundary layer; posteriorly from the internal limiting membrane of the retina by the posterior boundary layer, a layer less dense and less homogeneous than the anterior boundary layer. A hyaloid membrane does not exist. The only membrane which is situated between the retina and vitreous stops at the ora serrata, stands in close relationship to Mueller's fibers, and may justly be designated the internal limiting layer of the retina.

14. The zonula fibers break up into primitive fibrillæ prior to their insertion into the lens capsule. The anterior and posterior fibers divide gradually after they have reached the capsule, whereas the equatorial fibers divide into brush-like bundles before reaching the capsule.

15. The zonula fibers do not penetrate the capsule, but fuse only with the external surface. Their offshoots reach only the uppermost lamella of the capsule (Berger's zonula lamella, Retzius' pericapsular membrane), upon which they course a relatively long distance.

16. The equator of the lens is irregularly curved, showing a number of processes and depressions; the former being joined to the brush-like fiber bundles. The uneven equatorial contour must, therefore, be regarded as the result of the insertion of the zonula fibers.

17. No difference exists between the cellular elements of the vitreous and zonular space; all being migratory cells of mesodermal origin.

18. The zonula is developed from the anterior portion of the vitre-

ous. In the hyaloid tissue between the ciliary body and the lens a system of delicate connecting fibers appears at about the end of the fourth month of intrauterine life. These fibrillæ are at first extremely delicate and often insert into the capillary vessels of the membranous lens capsule. The true vitreous gradually becomes differentiated from the zonular space anteriorly. This is followed by absorption of the remaining hyaloid tissue and vessels of the vascular membrane in the zonular space, leaving only the zonula fibers.

19. The zonula is a modified portion of the vitreous, organized for a particular physiologic purpose. Whether the vitreous is of mesodermal origin (Schoeler, Kessler, Koelliker, Schwalbe, Hertwig, Schultze, Retzius, Czermak, Cirincione) or of ectodermal origin (Tornatola, Rabl, Fischel,, Addario, Haemers, Wolfrum), one thing is certain, viz., that the zonula embryologically and anatomically belongs to the vitreous and not to the retina. Etiologically zonula and vitreous are very closely related.

Zonular cataract. LAMELLAR CATARACT. LAMINAR CATARACT. LAMINATED CATARACT. A form of cataract in which the superficial laminæ and the nucleus of the lens are transparent, a layer or shell of opacity being present between them. See p. 1556, Vol. III of this *Encyclopedia.*

E. Kruckmann (*Graefe's Archiv. f. Ophthal.,* p. 322, 1916) describes his new method of removing zonular cataract. A discission knife pierces the temporal portion of the conjunctiva in the horizontal meridian, 3 mm. from the limbus, and then the corneal margin to the center of the enlarged pupil, followed by a vertical incision of the anterior capsule from the upper pupillary margin, and by a horizontal incision from the nasal pupillary margin. Then the cortical matter is incised horizontally. From the temporal end of the incision the knife is introduced behind the cataract to dislocate it into the anterior chamber, where it can easily be cut into pieces from behind. After a few days a lance-shaped knife is inserted 3 mm. from the limbus subconjunctivally and at the corneal margin introduced into the anterior chamber and into the cataractous masses, which by gentle lateral movements are cut and then carefully removed. This method gives excellent results, so that glasses can be ordered after two or three weeks.

Zonular keratitis. See **Band-shaped keratitis,** p. 877, Vol. I; also **Cornea, Ribbon-shaped opacity of the,** p. 3440, Vol. V of this *Encyclopedia.*

Heath (*Prac. Med. Series, Eye,* p. 73, 1909) remarks that the opacity may be primary or occur in eyes blind from glaucoma or iridocyclitis. The opacities are punctiform and crowded together, forming a gray stripe across the cornea, occupying the exposed portion of the lid fissure. The disease progresses slowly. Sooner or later both eyes are involved. In some cases there are attacks of severe pain, but ulceration is never observed. Most cases were in men over 45. The pathologic basis of the condition is a hyaline degeneration of corneal cells that later become calcareous. Gout, renal disorders, loss of vital energy in the cornea through vascular changes, repeated irritation of the surface of the eye, as by foreign bodies, are etiologic factors. Graefe noted a resemblance to glaucoma and bad effects of atropin. Sight has been improved by scraping the cornea and by iridectomy. Carbonate of soda, nitric acid, hydrochloric acid, 5 per cent., have been recommended. In Heath's case, scraping and applications of weak carbonate of soda solutions were of no avail. Iridectomy resulted in vision of 15/lx, where the patient had been unable to get about alone.

Zonular opacity of the cornea. See **Zonular keratitis.**

Zonulitis. Inflammation of the zonule of Zinn.

Zonulotome, Gradenigo's. See pp. 1518 (illustration) and 1519, Vol. III of this *Encyclopedia.*

Zonulotomy. Kuhnt (*Oph. Year-Book,* p. 329, 1909) proposes an operation for division of the zonule, and discusses the different conditions in which it is desirable to resort to it. If the pupil be incapable of normal dilatation a small preliminary iridectomy is first to be done. When the eye has fully healed from this operation, a discission knife or knife-needle is introduced subconjunctivally through the limbus, with the cutting edge turned toward the part of the zonule to be divided; and passed back between the edge of the lens and the ciliary processes, with care to avoid wounding the latter, or plunging the knife unnecessarily into the vitreous. If an extensive division of the zonule is to be made through a small coloboma in the iris, it is made on one side of the coloboma at one sitting, and subsequently the knife is introduced on the other side of the coloboma, to make an additional division. Kuhnt believes this operation should be used as a preliminary to reclination of the lens, in shrunken or tough membranous cataracts and for the division of cicatricial membranes likely to drag injuriously upon the ciliary body.

Zoöpsia. A hallucination in which the patient thinks he sees animals.

Zorab's operation. Aqueoplasty. See p. 5557, Vol. VII of this *Encyclopedia.*

Zoster, Herpes, ophthalmicus. See p. 5882, Vol. VIII of this *Encyclopedia.*

Zusammengesetze Forbe. (G.) Compound color.

Zusammenstossen. (G.) Contusion.

Zygospore. Spores formed by the conjunction of the two sets of filaments (hypæ) of the spawn or mycelium of a fungus.

Zygotes. The product of the fusion of two isogametes or two gametes. See p. 7640, Vol. X of this *Encyclopedia.*

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F. A. SMITH